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THE LINOTYPE.

[*Report of the Committee on Science and the Arts.*]

[No. 1497.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, November 6, 1889.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred for examination,

OTTMAR MERGANTHALER'S LINOTYPE,

a machine system for preparing printing forms, respectfully

Report that: The said invention is the subject of a series of eighteen letters-patent of the United States granted to the said Ottmar Merganthaler, of Baltimore, Md., numbered and dated as follows:

No. 304,272, dated Aug. 26, 1884, entitled Matrix-making Machine.

No. 311,350, dated Jan. 27, 1885, entitled Producing Printing Surfaces.

No. 312,145, dated Feb. 10, 1885, entitled a Machine for Producing Stereotyped Plates.

No. 313,224, dated March 3, 1885, entitled a Machine for Producing Printing Bars.

No. 317,828, dated May 12, 1885, entitled a Machine for Producing Printing Bars.

No. 312,960, dated Oct. 27, 1885, entitled Matrix-making and Printing Machines.

No. 328,961, dated Oct. 27, 1885, entitled a Machine for Producing Type Bars.

No. 332,354, dated Dec. 15, 1885, entitled a Machine for Forming Type Matrices.

No. 344,974, dated July 6, 1886, entitled a Machine for Producing Type Matrices.

No. 347,818, dated Aug. 24, 1886, entitled a Machine for Casting Stereotyped Plates.

No. 345,525, dated July 13, 1886, entitled a Machine for Producing Type Bars and Matrices therefor.

No. 347,630, dated Aug. 17, 1886, entitled a Type Matrix and Mechanism for Distributing the same.

No. 345,526, dated July 13, 1886, entitled a Machine for Producing Type Bars.

No. 347,629, dated Aug. 17, 1886, entitled a Machine for Producing Type Bars.

No. 376,541, dated Jan. 17, 1888, entitled a Mechanism for Electrically Controlling Stamping Machines, etc.

No. 378,789, dated Feb. 28, 1888, entitled a Machine for Producing Type Bars.

No. 378,797, dated Feb. 28, 1888, entitled a Machine for Forming Type Bars.

No. 392,466, dated Nov. 6, 1888, entitled a Matrix Delivering Mechanism.

No. 303,846, dated Dec. 4, 1888, entitled Type Bar.

Copies of each patent are appended to this report.

As might naturally be inferred, this is a machine involving many inventions. Its purpose is to produce lines of printing characters, instead of detached type for printing,

and to do so rapidly, and thus supersede the usual work of compositors in printing.

The machine involves a mechanism controlled by a key-board resembling the key-board of the Caligraph or Remington typewriter, having upon it every printing character required from a font of types. This key-board controls the delivery and the placing of matrices so as to spell the several words; and, after the machine has automatically spaced the words apart so as to justify, as the printers term it (or make an even distribution of spaces between all the words of the line so that the last letters of each line occur at the same length of strip), the line of characters is cast, and the sides are dressed, so that a series of such lines may be assembled in columns to produce the desired printing forms.

A considerable part of the series of inventions consists in the apparatus for preparing parts of the machine and in appliances for detecting and checking errors. The machine not only assembles the matrices into the form of a mould, but also, after casting the line of letters automatically, distributes the several matrices into the cases or tubes from which the machine draws them ready for repeated use.

Fig. 1 of the drawings shows the machine as it appears in use. It consists of a series of upright, flat, parallel tubes of brass, of such size that the matrices can slide down them freely, which tubes are arranged in a series in front of the operator, and above and back of the manual or key-board. The several flat tubes are of graduated lengths, so that when the upper ends are at the same level the line of the lower ends inclines upwardly towards the right hand. Beneath the ends of these tubes is a trough, provided at the right or upper end with a tube, from which a blast of air is constantly forced.

The matrices are held in position in the several tubes by a pawl, upon which they rest, and when wanted are released by the pawl being retracted by pressure on a key appropriate to the tube and matrix contained therein, so that to deliver any matrix from any of the tubes into the inclined trough, an operator has only to depress the key bearing the mark of that character, and the blast of air

drives the matrix downwardly into line ready to form the mould. The setting of type proceeds regularly in this manner by playing upon the key-board by the fingers of the operator, and the spaces between the words, formed by the matrices, are filled by double oblique slides, so that when a line of matrices is set up, between each word, or wherever a space is required, there is a double wedge inserted. The line of matrices, when completed sufficiently to form the required line for the breadth of column, passes from the trough to the left between two plates which are clamped slightly so as to bring them into correct line. They are then released or the clamps are slackened slightly, and the wedges or inclined plates are automatically forced by the machine in between the matrices so as to press them apart and force the matrices at the beginning and end of the line into contact with stops, which limit the length of the line. The taper of the several wedges being the same, and all being moved at the same rate between the matrices, insures an equal spacing between the several words.

After the spacing has been effected, the clamps are tightened upon the matrices and metal is pumped forcibly into the moulds. Upon the edges of the matrices are formed characters which are presented to the eye of the compositor, so that he can read each character in the matrices as fast as he sets them up by manipulating the key-board, and should he detect any error he can remove the wrong matrix and replace it with a correct one before passing to the casting operation. After casting the strip or line of type in the manner described, it is discharged between scraping surfaces, which render it fit for immediate use.

After the casting operation is concluded the matrices are released, and by the sliding-frame or elevator which presented them to the caster are carried to the distributer, where they are suspended from a bar having graduated strips or tongues formed upon it which fit into notches formed in the matrix. These notches are of such form as to hold the matrix engaged until each matrix comes over the proper tube for that character. The differences of form,

while not easily appreciable to the eye, are such that no matrix can drop off the slide into the tube beneath it until it has reached the proper place.

The system of notches resembles somewhat the method of notching the keys of the well-known Yale lock. Connected to the upper part of each of these tubes is a strip forming an electrode of an electric battery circuit, and a second strip forming the opposite electrode. These electrodes remain open during the normal working of the machine, but should any matrix be stuck or fouled in entering one of the tubes, or turn into the wrong position, it produces a contact with the other electrode, and, operating an electro-magnet by the current so controlled, stops the motive power of the machine.

The motive-power of the machine is used to manipulate the clamping devices for closing the matrices into moulds and for pumping the metal into the moulds. Each of the matrix tubes can be detached from the apparatus in the event of a matrix becoming tight in it and sticking, and the work of distribution proceeds while the work of composition is in progress.

The forcing of metal into the mould is done by a force-pump from a vessel containing molten metal heated by gas-jets. The power to operate the machine is supplied by a belt, and the machine when in operation requires, besides the attendant, a compressed-air supply to move the matrices after they are drawn from the tubes to the mould, and gas supplied to heat the mould, and the propelling power supplied to operate the casting apparatus, and the apparatus for shifting the type and controlling the mould and returning the matrices to their respective tubes after they had been used.

The details of the construction of the matrices are shown in the drawing, and also the slide, with the graduated ridges or tongues upon it, by which the matrices are distributed to the proper tubes.

The most ready mode of submitting these inventions to a clear comprehension of their scope, is to follow the order of the several patents of the inventor as they have appeared in chronological order.

The characteristic feature of producing printing forms in relief surfaces is shown in patents Nos. 304,272 and 311,350.

In these, the attempt was made to produce such strips by indenting characters in a strip of papier-maché or its equivalent, and to fill up the matrix thus formed with molten metal or other suitable material adapted to produce a printing surface.

Figs. 2 to *9*, reproduced from these patents, illustrate this method. The resemblance of the first to the system of construction used in the well-known House printing telegraph, is conspicuous.

This is succeeded by patent No. 312,145, having some fifty-three claims, in which type bars, operated by a key-board, are made to produce stereotype matrices (*Figs. 10* to *14*).

This part of the invention is illustrated by fourteen sheets of drawings. The drawings exhibit a series of letters or matrices, which are duplicates of each other, each of which has formed on one of its edges, in regular order, characters and letters which the machine is designed to indent. These bars are arranged in parallel upright position so that they may rise and fall independently.

By the operation of raising and lowering the respective bars, so as to bring into action the desired letter on each bar which is to be printed in a line, any combination of letters may be produced. For instance, if the word "the" is intended to be produced, the first bar is moved until letter "t" reaches the impressing point, the second bar until letter "h" reaches the same point, and the third bar until the letter "e" reaches the same point, and so on. The bars are adjusted with the letters selected into a common horizontal line at the impressing or printing point. The resulting line of letters or type producing the desired words in the order desired are clamped, and an impression is formed of them from which the proper cast to produce the desired line of letters is made.

The next patent, No. 313,224, embracing seventeen sheets of drawings and seventy claims, illustrates the apparatus and method of producing a matrix bar. That is, in contradistinction from the other, this machine produces a

series of type characters and develops a matrix bar by taking an impression therefrom into which the cast is made. In this instance the matrices are provided in the bars instead of characters in the bars from which to produce matrices.

The preceding machines contain mechanisms that appear in the present machine, which is in principle substantially a type-casting machine, or rather a line-casting machine, having adjustable matrices in contradistinction from the earlier machine, which had adjustable type or punches from which to prepare matrices. *Figs. 15, 16, 17*, from the drawings of this patent, are here shown, in which the general resemblance of mechanism with that of the previous machines clearly appears.

From this point on, the development of the principle of setting matrices to produce a mould in which the line of type is cast follows.

The next important advance in the art by this inventor consisted in the substitution of separate matrices for each letter or character for the lines of adjustable matrices, each adjustable matrix containing the entire series of characters.

The machine embodying this feature is illustrated in patent No. 317,828, the drawings of which are here shown in *Figs. 18* to *23*, in which the shape of the separate matrices appear in *Figs. 21* and *22*, and the method in which they are passed from the tubes or guides by which they are stored for use by means of little hooks or latches, marked *f f*, in *Fig. 21*.

The general resemblance of the mechanism of this machine to previous machines clearly appears on simple inspection. A feature which appears in this machine, in addition, is an endless belt or carrier at the upper part, shown in *Figs. 18* and *20*, for carrying the matrices and the tubes after they have been used, and distributing them in their proper places for repeated use.

Many of the other patents are for details involved in the preparation of the parts of the machine, and whilst interesting and important in the working of it involve in the detailed description a greater length than could be tolerated in our report, and they involve the same general characteristic features as have been stated and shown in the preceding

illustrations. These several patents will be found with the others appended to the report.

The manner in which accuracy of alignment is secured, and distribution of the matrices after they have been used, are shown in patent No. 347,629, *Figs. 24* to *27*, and the method of conveying them to the trough into which they drop as selected, and the point where the casting is accomplished is also shown. *Fig. 28*, from said patent, shows a section of the distributing bar upon which the matrices are guided, and the means of separating or assorting them for distribution clearly appears from a view of these figures in connection with *Figs. 28* to *41*, both inclusive.

The device for justifying or utilizing the spaces between words in each line in the apparatus before the casting takes place is shown in *Fig. 42*, consisting of a wedge marked *Y*, with a small tapering block accompanying it, one of which being placed in each space between words, and all of these wedges being simultaneously forced until the ends of the matrices reach the limiting bars at the end of the mould, the spaces between the words become equal.

This operation is performed first, before the matrices are clamped tightly; the matrices are then pressed into the right line, and then this tightening of the wedges, or justifying pieces, as they are termed, occurs again, and finally the matrices are clamped tightly so as to form a mould; the metal is then injected into the mould by a pump from the cistern of molten metal, producing the casting of the complete line of type.

Where duplicates are required this casting operation is repeated as often as is necessary, and the several type bars thus produced pass through a dressing device which removes all fins or burrs or other objectionable excrescence which would tend to prevent their correct and proper assemblage in printing columns, and the matrices are then unclamped and passed into the distributing apparatus ready for repeated use. The casting operation is somewhat complex, and is illustrated in patent No. 347,818. It resembles in general the system of type-casting by pumping or forcing

the metal into moulds by a plunger pump practised in type-foundries, with automatic adjuncts for closing the mould, and after the mould has done its work to liberate the matrices for distribution for further use.

An ingenious provision occurs in this apparatus for checking imperfections in its operation, before any serious difficulty or mistake in the work could arise from it. In the event of any of the matrices becoming injured or impaired, or sticking so that they would not pass down the tubes properly, such deviation from proper motion produces a contact with an electric wire closing a circuit, bringing into play an electro-magnetic stop-motion, which arrests the motion of the machine and calls the attention of the operator to the defect. All the tubes are arranged for storing the letters in such a manner that they may readily be removed, emptied, and any defective matrix taken from them without disturbing the adjustments of the other parts of the machine.

The location of the electric conducting apparatus and the matrices is shown in *Fig. 43*, taken from sheet 1, of patent No. 378,798. The electrical conducting wire is located at the upper end of the tube at the side or front of the mouth of the magazine tubes marked *C*, and in the event of any matrix toppling over, the projections of it touch this conductor, and close a circuit which puts into operation an electro-magnet, and disengages a stopping mechanism, throwing off the motive-power from the machine. In the event of the matrix descending part way and then sticking in the tube, the matrix above it being unable to descend makes contact with the conductor and produces the same stopping effect.

The details of the matrix-delivering mechanism are shown in *Figs. 44* to *47*, of the drawing sheet 2, of patent No. 392,466.

Here it will be seen that a lever marked *J*, with two projections, reaches into the side of the tube or magazine slides containing matrices. On this lever, at the upper sides of the fulcrum, are projections marked at the upper end of the lever *d*, and at the one below the fulcrum, marked *e*. When

the one marked *e* projects into the tube, so as to engage the projecting lug of the matrix, as shown in *Fig. 48*, the upper one is liberated from the matrix above, but before the lower matrix has descended from the projection *e*, the upper projection *d* engages the matrix next above it, so that but one can pass at a time. The disengagement of the matrix resting on the projection *d*, is attended or preceded by a motion of the projection *e*, ready to receive the matrix as it passes down, so that but one matrix can pass at a time. The keys of the manual or key-board are connected with the lower end of levers *j*, so that each key when depressed, working one of the levers *j*, delivers the matrix having the appropriate characters. The notches in the upper part of the matrix, with indentations, are the means of sorting them and distributing them by fitting on the corresponding ridges, upon the same principle that the different notches and projections of the Yale lock and its key determine the liberation of the lock bolt by the presentation of the proper key, and preventing any motion when any other than the proper key is introduced. The other projections and notching are for the purpose of guiding and holding the matrices as they are moved in line and clamped in the mould, the indentation, which appears at the right edge of each matrix, is the location of the letter which is sunken in it, and in this the metal flows to produce the desired character.

Your committee have visited the factories in Brooklyn and inspected the operations of the machine and the plant of the establishment for the preparation of it. There is shown in this manufacture a most unusual and extraordinary amount of ingenuity, not only in the machine itself, but the appliances for producing it, and ensuring accuracy in the several parts which enter into it, and that are required to be used in conjunction with it.

The perfection of work accomplished by it, and the rapidity of the work to be done, has been repeatedly reported in various publications. As a quick means for preparing forms for news, book and pamphlet printing, your committee believe these inventions deserving of the highest commendation. The tubes which hold the matrices are set in a

frame, and each frame carries a complete font. To change from one font or style of type to another, the frames have to be changed, and also so much of the mould apparatus as is required by the size of type and length of line desired. This may be done in a few minutes, but manifestly the best use of the machine will be in establishments where frequent changes will not be necessary. Your committee do not think that such a machine could ever become an adjunct of job printing, or printing where variations from one font of letter to another is requisite. In fact, it is not intended for this service. In conclusion, for the rapidity and excellence of its work and for the economy resulting in the class of work to which it is applicable, your committee feel justified in recommending the award of the ELLIOTT CRESSON MEDAL to the inventor for the ingenuity displayed in this machine and system.

[Signed] LUTHER L. CHENEY, *Chairman*,
S. LLOYD WIEGAND,
WM. H. WAHL.

Adopted, December 4, 1889.

S. LLOYD WIEGAND,
Chairman of the Committee on Science and the Arts.

THE ELECTRICAL EXHIBITS FROM THE UNITED STATES AT THE PARIS EXPOSITION.

By CARL HERING,
Delegate of the INSTITUTE.

The following compilations will give an approximate idea of the relative importance and extent of the exhibits from the United States, in Class 62, "Electricity," as compared with those from other countries.

The number of exhibitors in this class were as follows:

France, about	360	Chili,	2
United States,	28	Uruguay,	2
Great Britain,	19	Germany,	1
Belgium,	13	Japan,	1
Switzerland,	8	Luxemburg,	1
Russia,	5	Norway,	1
Portugal,	4	Finland,	1
Austria,	3	Argentine Confederation,	1
Mexico,	3		
Italy,	2	Total,	455

In a total of 455, France had 360, leaving 95 foreign exhibitors. Of these, the United States had 28, which is, therefore, about one-third of all the foreign exhibits. England comes next, having one-fifth. France had 79 per cent. of the total number of exhibitors; United States, 6·2; Great Britain, 4·2; Belgium, 2·8; Switzerland, 1·8; Russia, 1, and the rest together, 5 per cent.

Of the fifteen members of the electrical jury, France had 10—Mascart (President), Potier (Reporter), Deprez, Fontaine, Fribourg, Huet, Postel-Viney, Sciama, Sebert, Trotin; United States, 2—Abdank, Hering; Great Britain, 1—Preece (Vice-President); Switzerland, 1—Turettini (Secretary); Belgium, 1—Rousseau. Besides this, there were five supplemental jurors; France had 3, Great Britain and Belgium, each 1.

The floor space occupied by our electrical exhibits was 967·25 square metres or, in round numbers, about 1,000 square metres. That of the French Section was about 2,000

square metres, not including the eight or ten stations distributed about the grounds for lighting. We, therefore, had about one-half as much floor space as France itself.

The floor space occupied by the other foreign countries cannot be determined with any accuracy, owing to the fact that the exhibits were together with numerous others and were very much scattered about the grounds. From a rough estimate, however, it appears that Switzerland comes next, then Belgium and then Great Britain, the others being all quite small. The space occupied by the United States was about equal to, if not somewhat greater, than that of all the other foreign countries combined.

However, the importance of an exhibit is by no means proportional to the space it occupies. Neither will the number of exhibitors represent the importance of an exhibit. These figures merely give an approximate idea of the extent of our exhibit as compared with that from other countries.

A better comparison of the real values of the exhibits may, perhaps, be had from the number and nature of the awards made by the jury, as that eliminates entirely the space occupied, and in a measure, also, the number of insignificant exhibitors. The awards made by the jury were as follows, in order of their value: Grand prize, gold medal, silver medal, bronze medal and honorable mention. Now, the mere total number of awards given to the different countries would by no means represent the value or importance of the exhibits from those countries. It is absolutely necessary, if any summation at all is to be made, to give the different awards some definite relative values. Such a relative scale is difficult to determine upon, as it is almost entirely a matter of opinion. Different persons have entirely different views regarding it, depending on what award they received or did not receive, as well as on the award which their neighbor received. It is certain, however, that an arithmetic scale of relative values of 5, 4, 3, 2, 1, does not express the relative values of the different awards. The importance of the higher awards increases much more rapidly. A geometric scale of values would

give a much truer value and, therefore, the following scale will be assumed here, as representing a fair average value: Grand prize, 20; gold, 10; silver, 5; bronze, 2; honorable mention, 1. By multiplying the number of the awards by their respective values on this basis, the totals obtained can then be assumed to give fair relative values.

The awards made to electrical exhibitors in the different countries, and their relative values on this basis, were as follows:

	Order of Succession.	Grand Prize.	Gold Medal.	Silver Medal.	Bronze Medal.	Honorable Mention.	Total Relative Values.	Total Relative Values in Percentage.	Percentage of Number of Exhibitors.
France,	1	6	30	48	58	67	843	65·2	79·0
United States,	2	4	6	4	2	2	166	12·8	6·2
Great Britain,	3	1	4	4	3	2	88	6·7	4·2
Belgium,	4	. .	5	3	2	1	70	5·4	2·6
Switzerland,	5	1	3	2	2	1	65	5·0	1·8
Russia,	6	. . .	2	. . .	2	1	25	1·9	1·0
Germany,	7	. . .	1	. . .	. . .	. . .	10		
Luxemburg,	8	. . .	1	. . .	. . .	. . .	10		
Japan,	9	. . .	. . .	1	. . .	. . .	5		
Uruguay,	10	. . .	. . .	. . .	2	. . .	4	Together, 3 per ct	Together, 5 per ct.
Italy,	11	. . .	. . .	. . .	1	1	5		
Finland,	12	. . .	. . .	. . .	1	. . .	2		
Austria,	13	. . .	. . .	. . .	. . .	1	1		
Portugal,	14	. . .	. . .	. . .	. . .	1	1		
Norway,	15	. . .	. . .	. . .	. . .	1	1		
Totals,		12	52	62	73	78	1294	100	100

It will also be seen from the above that the United States has one-fifth as much as France, twice as much as England and about two and a half times as much as Switzerland and Belgium. It had four times as many grand prizes as any other foreign country, more gold medals, and as many silver, as any other. It received one-third of all the grand prizes, and about twelve per cent. of all the gold medals.

As far as awards are concerned, there were nineteen exhibits from the United States. Eighteen of these exhibits, or ninety-five per cent., were awarded, as in the above table; twenty-one per cent. received grand prizes, thirty-two per cent. gold medals and twenty-one per cent. silver medals.

The awards were as follows (in alphabetical order):

Grand prize: American Bell Telephone Company, Edison, Elihu Thomson, Elisha Gray.

Gold medals: American Graphophone Company, Cobb Vulcanite Wire Company, Heissler Electric Light Company, Okonite Company, Sprague Electric Railroad and Motor Company, Western Electric Company.

Silver medals: Commercial Cable Company, Consolidated Telegraph and Electrical Subway Company, Electron Manufacturing Company, Sperry Electric Company.

Bronze medals: Electric Supply Company, Solar Carbon Company.

Honorable mention: American Nickel Works (Wharton), Munson Lightning Conductor Company.

Some idea as to the importance of the electrical exhibits, in comparison with the other exhibits from the United States, may be had from the number of grand prizes awarded in the other classes. There were in all fifty-three grand prizes awarded to United States exhibits; four of these, or 7·6 per cent., were for electrical exhibits. One class received nine; two classes, four; one class, three; five classes, two; twenty-three classes, one. But this is not a fair comparison, as twenty-seven (over half) of the grand prizes were for public institutions and government exhibits. Eliminating these, there remain twenty-six grand prizes to companies, manufacturers and inventors. Out of these, electricity was the only class receiving four, or 15·4 per cent. Four other classes received two each, and fourteen classes, one each.

Among the great, successful inventions in the practical application of electricity, the United States may claim the telegraph, the telephone, the incandescent light and, unquestionably, the microphone* also; France, the accumulator and the Gramme ring; Italy, the battery and the Pacinotti ring; England, the self-exciting dynamo; Germany, the drum armature; Russia, the commercial arc lamp.

*Although Hughes made the invention in England, he had lived the greater part of his life in the United States and had obtained his whole education there, which led him to the invention.

A MACHINE FOR WEIGHING OFF, AUTOMATICALLY, AN EXACT AMOUNT OF YARN.*

The object of the machine is to weigh off rapidly and with precision an exact predetermined amount of yarn and to wind it into balls or otherwise, into the form in which it is to be sold.

It consists essentially of a pair of scales, an apparatus for feeding the yarn on to the scale pan, an apparatus for stopping this feed at the proper time and a machine for winding the measured amount of yarn into a ball or any other desired form.

The yarn is placed in skeins, as it comes from the spinning machine, on to two reels or rollers above the machine. The thread passes loosely between a pair of smooth jaws like those of a vise, thence between a roller and an idle pulley resting on it, and finally into a light cylindrical box of tin, which is the scale pan of the weighing scales.

By means of a chain gearing and a large wheel, this roller is turned rapidly (by hand or by other power) and pulls the thread of yarn off the skein and into the box as long as the idle pulley rests against the roller. The tin box into which the yarn is thus fed is on one arm of a pair of scales, on the other arm of which is placed the required weight. On the weighted end of the scales there is a wire dipping into a mercury cup, thereby keeping an electrical circuit, from a battery or small dynamo, closed, as long as there is not the required amount of yarn on the pan. In this circuit there is a powerful electro-magnet, the armature of which is secured by levers to the idle pulley and vise jaws described above. As soon as the yarn, which is being fed on to the scale pan, is sufficient to counterbalance the weight on the other arm of the scales, the tilting of the scale beam opens the electric circuit at the mercury cup and thereby relieves the armature of the magnet, which in

* Exhibited by Mouchére, in the French Section, in Class 54 (Appliances and Methods of Spinning and Rope Making).

turn raises the idle pulley from the feed-roller, thereby stopping the feed and closes the vise jaws, which then hold the thread securely at the required point.

An empty scale pan is then put in place of the one which is full, and while the second quantity is thus being weighed off, the first is simultaneously wound into a ball by a simple winding apparatus attached to and operated by the same machine.

The success of the machine seems to be due to the fact that the weighing and the winding are not one and the same, but are two successive operations.

The precision with which the yarn can thus be weighed, depends evidently only on the sensitiveness of the balance used.

Instead of *opening* a circuit when the required weight is reached, the apparatus might be arranged to *close* a circuit, thus economizing current. But the latter would have the disadvantage, that should the current from any cause fail, it would not render itself evident, as in the reverse arrangement, in which, if the current fails, it stops the feed.

CARL HERING.

NATURAL HISTORY IN ELEMENTARY SCHOOLS.

BY DR. H. HENSOLDT,
School of Mines, Columbia College, New York.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *November 18, 1889.*]

Prof. PERSIFOR FRAZER introduced the Lecturer, who spoke as follows:

LADIES AND GENTLEMEN:

Another few weeks and we shall enter upon the last decade of this our nineteenth century, a century which will be forever memorable when it passes into history as one of progress unparalleled in the annals of the human race: for no matter to what heights the genius of the inventor or the daring of the scientist and philosopher may yet rise in the ages that are to come—the one in conquering

difficulties which to us seem insuperable, and the other in establishing new truths of which we do not dream—no matter, I say, to what pinnacles of culture mankind may yet attain, the nineteenth century will be forever memorable, because it will be pointed to by those who come after us as the century during which a rational and systematic inquiry into the problems of that physical world which surrounds us was for the first time successfully inaugurated, and that marks the commencement of a new era in the history of human progress.

A century may be a long or a short period in the life of a nation, according to the rate of its mental or material development. When the great Napoleon had marshalled his forces in Egypt, on the eve of a memorable battle, he pointed to the Pyramids and addressed his soldiers in one of those short, stirring speeches, for which he was unrivalled, commencing with the words: "Behold! forty centuries are looking down upon you!"

Six months ago, the people of these United States celebrated the centennial of the inauguration of their first president, the immortal Washington, and emphasized in a manner worthy of so great an occasion the close of the *first* century of their existence as an independent nation. I saw the festivities in New York and witnessed the enthusiasm, which seemed to be universal and to extend even to the very immigrants who had landed as it were but yesterday, and when I gazed on that mighty industrial parade, on Wednesday, the 1st of May, in which the triumphs of inventive skill, of industry and commerce, of science, art and literature, as well as the achievements of almost every trade or profession, were symbolized in a manner more or less beautiful, grand and impressive; when I beheld that huge procession, which seemed as if it would never end, I could not help thinking that in this *one* century, thus fittingly brought to a close, *more* had been accomplished for humanity, more for liberty, morality and real progress than during all the long ages which had preceded it, more than during the forty centuries, which were looking down upon Napoleon's soldiers, when they fought that memorable Battle of the Pyramids.

Now, I do not here propose to give a detailed account of the great things accomplished during this or any portion of the last century, or to compare the present state of our knowledge with that possessed by our forefathers at any given period. What I desire is to argue a question which I believe to be of no small importance to all of us, inasmuch as it will surely be forced upon our attention sooner or later, which is destined to become a subject of bitter controversy and which we can no longer afford to ignore.

The question is this: Are our present methods of disseminating knowledge, or better perhaps, are the views still held by the majority of us as to what constitutes elementary knowledge, to what subjects instruction should be chiefly or exclusively limited in our public schools, and what is the order of their importance—are our methods and views in reference to these vital matters really in harmony with the spirit and the requirements of this enlightened age—can we in the achievements of pedagogy trace a progress corresponding to the vast strides made in other directions, affecting interests of equal importance to mankind? Are we really moving in the right direction and is the instruction which we administer indeed such as best fits those entrusted to our care for the contingencies of that great and bitter struggle for existence, which they have to face, in which the strongest ever triumph and the weakest are mercilessly driven to the wall.

I am not here referring to mere technical *methods* of instruction; indeed, I would be the last among you to propose or lay down rules as to how a teacher should proceed in the interpretation or treatment of this or that subject before his class. I believe in the utmost liberty and latitude in this direction, for in my opinion it is a supreme folly to take it for granted that a vast body of teachers will be able to instruct pupils after a uniform and narrowly-defined plan. As there are no two persons in this world alike in every respect, either in their physical or mental characteristics, so, I venture to say, there are no two teachers, who, if left alone, would exactly agree in their mode of teaching. Every teacher has a method, manner or style peculiar to

himself, in which he can do his best. He knows this by intuition and it is always well not to interfere with him. A certain method may suit the disposition and temperament of a certain teacher and he may come to look upon it as the only road to success; but another, who sees the world in a different light, takes a different course, with the same result.

My object in addressing you to-night is to offer something like a plea for the study and the teaching and dissemination in the widest sense of those natural sciences which, if they did not all originate in the nineteenth century, have advanced at so gigantic a pace within recent years, within the memory of most of us, and which, indeed, were mainly instrumental in bringing about that unparalleled and sudden progress for which our age will be forever famous.

We are hampered in our educational work by much that is purely traditional, much that has been handed down to us by former generations, from a time when it was of real service and importance to mankind, but which is now of very questionable value, and more of a hindrance than an advantage. I am alluding here not merely to the so-called "classical" languages, but to any kind of training which is purely or mainly linguistic, literary or historical, and in a certain sense also to the exaggerated importance which we attribute to the study of mathematics.

There *was* a time when the greatest achievements of the human race, in poetry, science and philosophy, were locked up in the literature of ancient Greece and Rome, when the foremost elements of culture were accessible only to those who could master the Greek and Latin languages. During that long middle age of Europe down to the seventeenth century, when science and philosophy were at a standstill, when—if anything—there was even retrogression, so that important truths, discovered of yore, became lost, and torture and death at the stake threatened those who pried into the secrets of nature and dared to make known their discoveries, when the languages of Europe were rough, uncouth and poor in words, *then* the study of Latin and Greek, for

instance, was justified, was necessary for those who were yearning for refinement and culture, or, as we should say, a liberal education.

It is not so now. Our modern languages, the English, French and German, have risen to as great a height of technical perfection, have accumulated a wealth of words and acquired a grace and fluency of expression equal at least to that of Greek and Latin; our great standard works of prose and poetry are equal, if not superior to those of classical antiquity, while in science and philosophy we have left the ancients far behind.[1]

There is no reason whatever why either Greek or Latin should be studied in this nineteenth century, except by philologists and historians on professional grounds, but there is every reason why these fossil languages should be dropped, once and forever, from our educational programme. They have fulfilled their mission and are now only an encumbrance, and that they should have held their position in public opinion so long, as essential elements of culture, is simply owing to the fact that we have not even yet got quite over the scholasticism of the middle ages, when culture and refinement were identified with classical learning.

I know that in our efforts to eliminate or restrict the teaching of these now useless languages we shall have the determined opposition of a vast body of schoolmen and others who have wasted—or let us say devoted—the best part of their lives to the study of these languages, and who live under the bane of a pedantic scholasticism, inherited from the past. There will be a great howl raised by those who are linked to the old system with all the ties of interest, prejudice and conceit, but the great wave of public opinion is rising against it, slowly perhaps, but with increasing force, its crest may tower above us to-morrow, and it will surely sweep away these anachronisms once and forever!

Why are we clamoring for the abolition or restriction of such things as Greek and Latin? Because we wish to teach the rising generation something of greater value instead.

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[1] See note at end.—F.

This is an utilitarian age, an age of commercial and industrial activity, such as the world has never seen before, of business enterprise and competition, of ceaseless toil for material progress. This is no age for classical languages! Man's wants have increased, therefore he must toil more, for good or for evil.

When man lived in a simpler or less luxurious manner, as our forefathers did 150 years ago; when he was satisfied with an unpretentious, homely dwelling, with simple and frugal fare; when a coat would last him for a dozen years; when he did not consider it necessary to half ruin himself rather than be outdone by his neighbor in extravagance, then he could afford to study Latin. His requirements were few and he had little to worry him; he knew not the care, anxiety, responsibility which besets us nineteenth-century mortals. He had no train to catch and therefore was in no particular hurry; he could afford to sit by his fireside and enjoy the ancient classics.

To-day it is otherwise. To-day the best part of man's life—and, alas! too often the whole of it—is a struggle for mere existence, a struggle for the bare necessaries of life, and there cannot be a shadow of a doubt that this struggle will deepen and become yet more severe in the future. To-day, the education of the rising generation should be so directed as to prepare it in the best possible manner for the contingencies of nineteenth-century existence, to equip it for that desperate struggle which it cannot escape. To-day we cannot afford to teach our children a complicated ancient language like the Latin, however perfect, grand and beautiful, the mastering of which requires long years of severe study, because it is of little or no practical value to them in the struggle for existence, because we have to teach them things of infinitely greater importance, not only in a direct and material, but in a disciplinary and intellectual sense.

The natural sciences, to the development and application of which the progress of this age is mainly indebted, have been too long neglected in our schools, have been treated with indifference, or even studiously ignored, while useless scholastic rubbish, the heritage of an indolent age, has been

carefully retained, nursed, propped and bolstered up in the most preposterous fashion. We teach our children Latin and, if possible, also Greek, if not in our ordinary elementary schools, yet in most of our high-schools and colleges; we burden them with a lot of literary and historical ballast, equally traditional and of very questionable value; we torture them with technicalities of grammar which are of absolutely no use to them; but we leave them almost totally unacquainted with that great and wonderful nature which surrounds them, that nature in which they have their being, from which they draw their sustenance, which they have to face and conquer in a thousand different ways and upon a knowledge of whose laws their success in life mainly, if not entirely, depends.[2]

It is true, we teach geography, which, in so far as it is not mere political geography, may be regarded as a branch of natural science, and an important and beautiful branch it is, one which is peculiarly fitted to rank high in our educational programme, for it is more or less closely interwoven with all the others and could be made a vehicle for the dissemination of a vast amount of positive knowledge, especially in small country schools, where the teaching of so many distinct subjects is, for obvious reasons, out of the question.

It is true we teach mathematics—not in the strict sense a natural science, yet an important factor in our nineteenth-century life problem. We teach it in its various modifications of arithmetic, algebra, geometry, etc., and perhaps we even teach a little more of it than absolutely necessary, and have fallen into the error of over-estimating its value, for a thing, however excellent in itself, when overdone or obtained at too great a sacrifice, may prove anything but a blessing.

What, for instance, would you think of a farmer who, with a certain amount of capital for procuring an outfit, invested nearly every cent in the purchase of an exceptionally expensive horse, so that he would be obliged to do without a number of other necessary things, or have them of the

[2] See note at end.—F.

cheapest and poorest description. A horse for half the money would have done his work equally well, if not better, and he could then have had a good plow, a decent wagon, (and what not besides) that would have helped to ease his lot and make his life worth living. Yet that farmer is not half so irrational as we are in our undue regard for mathematics, for after all, his horse is his most important requirement, while algebra, geometry, stereometry and trigonometry, are of ultimate practical value to not one in a hundred of our pupils. These subjects should be taught only in their most elementary stages in our public schools; trigonometry and stereometry should be entirely eliminated and algebra never carried beyond exercises in simple equations; they should be left to special institutions for the training of those who desire to study mathematics for professional reasons; they have no business in our ordinary schools, where they only take up the time which could be devoted to something better, for as a mere means of expanding the intellect, of drawing out the mental faculties, they are vastly inferior to other educational disciplines, which I would advocate in their stead.[3]

It is true, we also teach physics, or, as it used to be more frequently termed, "natural philosophy," to a limited extent and after a fashion, in some of our schools; but what about chemistry, what about zoölogy and botany,[4] what about the great science of geology, with its subdivisions of palæontology, mineralogy and petrography, to say nothing of optics and astronomy—what about these? They may sound very formidable, but we must not let mere names prejudice or frighten us. They are the fruits of the world's best knowledge, ripened by the world's best intellect and reduced to order and system for the requirements of the present and the guidance of the future. Their importance is daily increasing and their elements are not more difficult to teach and to acquire than those of mathematics, nay, even less so.

Some of you might reply: Let these subjects also be

[3] See note at end.—F.

[4] See note at end.—F.

taught only in special institutions, such as technical schools, high schools, colleges, etc., keep them out of our elementary public schools. You would be mistaken! A knowledge of what has already been accomplished in these departments of science—however imperfect and fragmentary—would be of enormous advantage to those whom it is our duty to enlighten and instruct to the best of our ability. We must bear in mind that the education administered in our public schools is, in the majority of cases, the only school education which the children of the masses ever receive and that we are guilty of serious neglect if we fail to afford them at least an insight into the aims and methods of these great factors of modern advancement.

When we look around and examine into the views still held by a considerable section of the public—especially that possessed of the least education—on the study of natural science, its value or importance to the human race, we find much that may well startle and amuse us. We find that the popular conception of a naturalist is that of a man with long hair and spectacles, who goes about collecting slugs and bugs, shells, minerals, fossils, etc., for some occult and mysterious purpose, known only to himself. In small towns he is looked upon as a sort of crank; but to the farmer, who watches him in his erratic exploits, he is an object of great wonder and speculation, and either put down as a lunatic escaped from some neighboring asylum, or, if he has the good sense to wear ancient garments, as a fairly well-behaved specimen of the pauper persuasion, on out-door duty.

Now, the long-haired men (or short-haired women) whom you may observe in the fields, in the woods or on the sea-shore, hunting for insects, shells, fossils, etc., are, in ninety-nine cases out of a hundred, not naturalists. They are simply people with a hobby, people with a mania for collecting objects of a certain kind, which may be butterflies, beetles, shells or anything else pertaining to natural history. But they might as well collect postage-stamps, monograms, chinaware, walking sticks or queer-looking buttons for all the benefit science derives from their efforts.

Of course, he who wishes to study one special thing, with this or that special end in view, must devote himself more or less exclusively to it, if he would master it thoroughly and learn all about it. But, we do not propose in our elementary public schools to teach our pupils all about butterflies, or all about shells, all about mineralogy, chemistry, astronomy or other special department of science. What we desire is to afford them an insight into the methods of natural science in general, and—so long as they are under our guidance and influence—to give them a synopsis, as complete and perfect as we can possibly make it, of what natural science has already done and accomplished for mankind.

Take, for instance, astronomy. What could be more attractive and fascinating to the youthful mind; what could more powerfully stimulate the faculties of imagination and inquiry; what could develop in greater measure the perceptions of harmony, order and symmetry, than the revelations of that great science?[5] The man who can look at the stars every night without once troubling himself to think what they are and how they came to be there; who can see the sun rise in the east and set in the west, day after day and year after year, without once endeavoring to learn something of the nature and cause of these phenomena; who can gaze with indifference at the moon and its changes, at shooting stars and comets—that man's education has been wofully neglected, and he is a pitiful object—no matter how clever and cunning he may be in the art of cheating his neighbor.

Let us teach our children the elements of astronomy—not in a dry, pedantic fashion, according to this, that or the other text-book, not as if its comprehension depended on their knowledge of the approximate number of miles which separates the earth from the sun, on their ability to rattle off the names of the planets in the order of their succession from the solar centre, on the knowledge of this or that angle of obliquity, altitude, etc.; but the lucid astronomy of the

[5] See note at end.—F.

concrete, clear, plausible and free from technicalities, which is not beyond the comprehension of the less gifted of our pupils. The moment we begin to lay too much stress upon the element of mathematics, we depart from the true course, for then our teaching will invariably degenerate into a mere system of cramming.

Let us, I repeat, teach our children what we can of astronomy, for it is a powerful factor of mental development. It will afford them a glimpse into this great and wonderful universe, an idea of the true position of this terrestrial globe among the countless myriads of similar worlds; it will modify their views in after years and influence their daily lives even, for it will prevent a great deal of error, fanaticism and conceit.

Take the science of geology. If we desire our children to succeed in this world we should, in the first instance, endeavor to show them what this world really is. Geology teaches us, in a manner which is at once beautiful, impressive and convincing, all that is known of the constitution of this terrestrial globe and of its past history, for without a knowledge of the past much of the present would be forever incomprehensible. It tells us of the mighty changes which this planet underwent during those long æons, since the first thin crust began to form around a vast sphere of liquid fire. How the contraction of the huge molten mass, as it cooled more and more, caused great irregularities in the crust, gave origin to elevations on the one hand and vast depressions on the other, depressions which received the oceans of water, suspended in the atmosphere in the form of steam, which began, as soon as the earth had cooled sufficiently, to descend in a rain which may have lasted for thousands of years. It tells us how the conditions which rendered organic life possible were slowly and gradually evolved, and though it does not explain the *nature* of that marvellous step, when matter became first endowed with consciousness, yet it points out the period when the first organism, in all probability, originated.

That first organism, the celebrated *Eozoon Canadense*, one of the protozoans, the lowest class of organic beings of

which, as yet, we have any knowledge, originated in the ancient Laurentian epoch, and is found in the fossil state in certain limestones or calciferous serpentines of Southeastern Canada. On these Laurentian deposits rests the entire structure of sedimentary formations, the Silurian, Devonian, Carboniferous, Permian, Triassic, Jurassic, Cretaceous, Tertiary, up to the latest Alluvial, a pile more than a hundred thousand feet thick, every *inch* of which represents at least several centuries, so that for our *Eozoon Canadense*, the oldest known fossil, we get an age of something like 150,000,000 years.[6]

Geology teaches us how organic life, beginning with the lowest and simplest forms, became more complex as the ages swept by and rose to a higher level, and as we turn over the geological strata like the leaves of a book, leaving the older formations behind us, we observe an uninterrupted and steady progress towards a more perfect type. Sometimes, indeed, there is a halt, sometimes it would seem as if the foremost representatives of organic life, despairing of further progress, had settled down into a long period of stagnation, but suddenly this or that difficulty is overcome, new types appear, and the standard of progress is triumphantly carried another step forward.

Let us teach, in our public schools, all we can about geology. Let us describe the condition of the earth during that Laurentian epoch, when slimy protozoans were the only representatives of animal life; let us then picture to our pupils the characteristics of each succeeding epoch, telling them how the Silurian seas were teeming with shells, crinoids and sponges; how the first vertebrate animal, a fish, made its appearance in Devonian times; about that wonderful fauna and flora of the Carboniferous age, with its huge sharks and primitive reptiles on the one hand, and its gorgeous fern trees, Lepidodendrons, Sigillariæ and Calamites on the other; about the great Mesozoic period, the Triassic, Jurassic and Cretaceous, with its saurian monsters, veritable sea-serpents and flying dragons; the Tertiary, when the

[6] See note at end.—F.

earth shook under the giant step of the mastodon, and mammalian life rose and flourished as never since.

We can teach these things, can teach them in plain and simple language, and they will be better understood, more eagerly listened to, and of greater ultimate value to those entrusted to our care, than all the expositions of Euclid, mixed quadratic equations and parsing nonsense ever resorted to by hopeless incapables, and palmed off as education upon a credulous and unsophisticated public.

There is no time now for entering in detail upon the merits of the other branches of natural science, the mode of their interpretation or the advisability of their being included in our educational programme. Every enlightened teacher, who has kept pace with the intellectual progress of the age, who, if not stimulated by a nobler impulse, has at least considered it his duty to learn, in a general way, as much as possible about the present state of scientific inquiry, who in his leisure hours has read the lay-sermons of Huxley, instead of Ouida's latest novel or the works of Alexandre Dumas,[1] to whom the names of Cuvier, Agassiz, Darwin, Tyndall, Proctor and Dana are familiar; every enlightened teacher, I say, will know exactly how far to go, what to teach and what to omit.

Some of our modern pedagogues, no doubt, will reply: "How can we teach astronomy, geology, physiology, botany, etc., when we know nothing about these things? We have never bothered our heads about the stars, about minerals, rocks and fossils, about insects and plants. We have taught our pupils how to solve quadratic equations and have devoted the rest of our time to the parsing of long sentences." My answer would be: I am sorry for you! Your conception of this material universe must be a peculiar one. You have missed much that is grand and beautiful, have burdened yourselves with a good deal of dross, when gold was within reach. But I would also say: It is not too late for you *yet* to turn to natural science. You may not master it after the manner of a Huxley or Tyndall, who

[1] See note at end.—F.

themselves only excel in certain directions, for as Huxley has well put it "the days of Admirable Crichtons in science have long been over, and the most indefatigable of hard workers may think he has done well if he has mastered one of its minor subdivisions."

But you may learn what has been done in a general way, how far the torch of enlightenment has been carried by the foremost investigators; you can master the chief results of inquiry in every department of natural science and become adept in their interpretation.

Acquaint yourselves with the best popular science literature of the day; there is a whole world of fascination and delight in store for you! Read the popular lectures of Huxley, on man's place in nature, on a piece of chalk, on the lessons of palæontology. Read what Sir John Lubbock has written on the wonderful relations between insects and flowers, on the habits of ants, wasps and bees, where it is shown that the plant produces the flower for no other purpose than to attract the insect, in order to make a tool of it in effecting cross-fertilization. Read the essays on evolution of Grant Allen, that charming interpreter of Darwin and Herbert Spencer; the works of Richard Proctor on the marvels of the stellar world, written in language as beautiful as the very "Flowers of the Sky" of which they treat. They will fascinate you more than any novel ever perpetrated; more than your "She," "King Solomon's Mines" and "Count of Monte-Christo." Then your horizon will be widened beyond measure and you will perceive the boundless opportunities you have for the dissemination of knowledge, for next to the delight experienced in the acquisition of a new truth I know of no greater pleasure than that of communicating it to others.

Of course I do not advocate the establishment of a lot of professorships for the teaching of this or that distinct branch of natural history in little country schools, or even the devoting of so many hours each day to so many separate subjects. Nor do I recommend the purchase of a lot of expensive apparatus. Where such things can be done within reasonable limits, well and good, so much the better

for the particular community; but there is no necessity for turning our elementary schools into science laboratories. Every teacher of a country school, no matter how small or how poor, can and ought to teach a modicum of natural history. Several years ago, when I had charge of an elementary school, I arranged matters so that most of the science teaching was crowded into the lesson nominally devoted to geography. But, then, this geography lesson was made a prominent feature of the instruction, and I usually reserved the last school hour for it. When describing the physical characteristics of a certain continent, island or mountain system, I could bring in geology and teach some of its cardinal doctrines. The illustration of the position of our globe as a member of the solar system naturally led to astronomy, physics and even chemistry. The description of the most important natural or artificial products of a country or region afforded an opportunity of entering upon the physiology of plants; on the habits of animals; on the general principles of biology. Ordinary objects, collected in the woods and fields or in the river were used in illustration with great profit. Excursions were frequently made to interesting localities, which gave great delight to the pupils, stimulated their enthusiasm and proved of enormous advantage in the interpretation of natural phenomena: and I may truly say that to my pupils that geography lesson was always the event of the day, was the lesson most eagerly anticipated and most reluctantly quitted.

When teaching the elements of natural history the teacher should be especially on his guard against the temptation of giving undue prominence to a particular subject for which he may have a personal preference. If he is particularly fond of astronomy, for instance, he cannot well avoid showing it, but let him beware of teaching it to the total exclusion or at the expense, as it were, of the rest of the natural sciences. This duty is to lay the foundation of a broad general education and not to teach all about one special thing. Nothing is more mischievous than a hobby on the part of a teacher who is charged with the responsi-

bility of administering an education which, as I have already pointed out, is, in the majority of cases, the only school education which the pupil ever receives.*

I remember a teacher whose particular mania was mathematics, which he taught to the exclusion of almost everything else, till his pupils' hair stood on end. His blackboards were always crowded with algebraical symbols and geometrical figures; it was arithmetic, algebra and geometry from morning till night. He had come to consider mathematics as the essence of all human wisdom, and his conceit as a mathematical expert was only surpassed by his profound ignorance of almost everything else. He invited me to his examination, in which he took great pride. His pupils worked equations and geometrical problems, you could hear of nothing but x, the square of x, and the root of x, of angle this and angle that, and I assure you, the parents, simple-minded farmers, sitting around on the benches and listening in mute astonishment, with their mouths agape, were a sight not easily forgotten. No doubt they went away congratulating themselves on having secured a pedagogue who could teach things so utterly beyond their comprehension.

I remember another teacher whose hobby was English grammar—dry, technical grammar—especially the iniquity notorious under the name of "parsing." His pupils could rattle off any sentence in the most approved and orthodox fashion of twenty-five years ago, but their command of the real language, as almost invariably is the case with those who are strong in grammar, was *inversely* proportional to their knowledge of parsing.

The practice of parsing, by the way, once almost universal in the schools of England, has of late been more and more abandoned, as its uselessness is now recognized by every enlightened schoolman. No orator, poet or writer of any sort has ever acquired command of his language by the aid

* This applies only in a limited sense to high schools and all larger educational establishments. In the case of teachers placed in charge of special departments of science, it is, of course, both natural and proper that they should confine themselves entirely to their departments.—H.

of a system which for utter uselessness and absurdity is unparalleled in the history of human folly.

Ladies and gentlemen, I thank you for the patience and courtesy with which you have listened to this address. I thank you all the more as I am fully aware that many of the opinions which I have advanced will not be shared by you, that I have said much with which many of you can and will never agree. And I know, furthermore, that to listen to an exposition of that which does not coincide with our views is sometimes anything but pleasant to us. That is human nature. I should be sorry if, without intending it, I have hurt the feelings of one or the other among you who may have very pronounced views in favor if this thing or the other which I have denounced. We cannot all be expected to think, argue and act alike, if so we would be a dreary and monotonous world indeed. It is difficult to find two human beings who hold the same views on a given number of subjects—nay whose opinions exactly coincide even in one special direction. Everyone lives in his own sphere of thought, argues and judges from his own individual standpoint, which is conditioned by circumstances of education, interest and inherited tendency. I have no mean of knowing in what light this world may appear to my neighbor. He may see things of which I do not dream, while I may be powerfully impressed by others which to him are an unknown quantity.

I advocate no violent measures. Do not run away with the idea that I would like you to discard the whole of mathematics, or to throw forthwith all grammar overboard. As to what I have said about Greek and Latin I am afraid I shall have every classical scholar among you up in arms against me. But I am no fanatic even on this point. Having received my earliest education at a "Gymnasium"*

*The Gymnasiums of Germany are not institutions for the training of youth in gymnastic or athletic sports, as the name would seem to imply, but admirably organized grammar schools, the principal function of which is the preparing of pupils for the universities. No German is admitted as a regular student to any of the universities of the fatherland, unless he has previously gone through the orthodox routine of the Gymnasium, where Greek and Latin are cultivated to a most inordinate extent.—H.

in Germany, I could not myself avoid learning something of these languages: and though they could never rouse my enthusiasm, yet I have often longed for leisure that I might penetrate deeper into them and acquire a fuller appreciation of old world grandeur and beauty.

All I plead for is that neither of these educational disciplines should be carried to an absurd extreme in our public schools, or cultivated at the expense and to the exclusion of other equally important branches of knowledge.

Natural history is knocking at the door of our public schools, clamoring for admission; be wise in your generation, make some concessions, do not let it plead in vain! Give it a place, however modest, in your educational programme, and if it cannot be done without lopping off something here and something there, use the pruning-knife with firmness and discretion. Teach all you can of it, teach it without a text-book, if possible, but if this is beyond your power, use a dozen text-books rather than not teach it at all.[8]

NOTES BY PROF. FRAZER.

[1] This appears to be too sweeping a statement as to philosophy, in which we have but worked on the lines laid down by the early Greeks with more material at our command. The same objection must be made to the statement in regard to modern languages. The Greek and Latin languages have instructed those who have made English, French and German what they are. As well declare the uselessness of the study of old masters by modern artists, or the study of Littleton and Blackstone by modern jurists.

[2] A great change has taken place in this respect. No boys' or girls' school would be patronized, in which the elements of natural science were not taught.

[3] What better use can be made of the time of an elementary student than instruction which fits him to express and to measure what he sees? Without this instruction as a preliminary, original research is impossible. It is not too much to say that the education in the exact use of language has a moral as well as a material side, for much of the world's lying is due to carelessness in searching for words and ways to express one's precise meaning, and the indifference to exact truth which such carelessness begets. It would seem that the elementary school was the place to acquire a knowledge of the methods of determining the solid contents of a body (stereometry),

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[8] See note at end.—F.

the unknown angles and sides of a triangle from those known (trigonometry), and the means of determining values involving square and cube roots (quadratic and cubic equations). Until consistent notions on these subjects are had, progress in natural science would seem to be an idle mockery. The relative value of these studies as exercises in thinking, is a matter of opinion.

[4] The elements of all these sciences are taught in the larger number of first-class schools.

[5] How could one learn the barest definitions of astronomy without a preliminary knowledge of geometry and trigonometry?

[6] We dare not teach our children this, because not only are we in ignorance of the true history of *Eozoon Canadense*, but a very large majority of the best geologists of the world do not accept it as a fossil organism at all. (See "Report of American Com. to Int. Geol. Cong. at London," pp. 35 and 43, Frazer, and "The Azoic System and its Subdivisions," Whitney and Wadsworth, pp. 528 *et seq.*) Some inches of the strata may represent much less than a century, and we are entirely unable to approximate to the number of million years represented by the post Laurentian measures.

[7] No man who amounts to anything works on his subject all the time. The intellectual leaders of our age read novels, and most of them enjoy Alexandre Dumas. Life is usually long enough to read the scientific books cited and good novels, too.

[8] While it is unusual for the Professor or Editors to make critical comments on a lecture printed in the JOURNAL, this plan was adopted with the full accord of Dr Hensoldt as the best, and indeed the only one, in this case; for it enables his lecture to be printed verbatim, though the former dissent from some of his views. It would not be just to Dr. Hensoldt to make an issue with him here on the subjects which he has touched upon, and the undersigned will only say that while he sympathizes with the object of the above lecture, which is to extend the field devoted to study of natural science in the elementary schools, he cannot agree to the means which the lecturer proposes, *i. e.*, to banish altogether Greek, Latin and grammar, and to interdict stereometry, trigonometry and quadratic and higher algebra, in order to make room for more natural science. The law of growth requires first, the training of the senses, then the perfection of speech, and later the practice in abstraction and mental processes. Of course, an honest difference of opinion may exist as to how much the studies placed by Dr. Hensoldt under ban conduce to this end.—F

THE EVOLUTION OF RAILROAD SIGNALING.

BY C. HERSCHEL KOYL.

[*A lecture delivered before the* FRANKLIN INSTITUTE, *November 25, 1889.*]

The Lecturer was introduced by the Secretary of the INSTITUTE, and spoke as follows:

MR. CHAIRMAN, LADIES AND GENTLEMEN:

Possibly in the days before the word evolution was used in its scientific sense, there may have been justice in the question whether spectacles were made to suit the nose or the nose originally designed with reference to the coming spectacles; and in the mind of the enthusiastic signal inventor, it seems not always clear whether his signals are for the benefit of the railroad, or railroads were built for the purpose of using his signals.

In our discussion, however, we will consider first the railroads and the various combinations of tracks, and, second, the manner in which the needs of the railroads have brought about various systems of signals and have determined their present forms.

Railroad signals comprise fixed signals on posts, fixed switch signals on stands, signals on trains, a system of hand signaling, and some others; but the time at our disposal will allow discussion, and that but brief, of not more than one general class, and we select the fixed signals as showing most clearly the process of evolution.

The accompanying illustration, *Fig. 1*, shows (1) the simplest case of railroading for which signals are necessary, that of trains following one another on tracks in which the traffic is always is one direction; (2) a case in which the signaling is rather more complicated, though still simple, that in which tracks cross on the same level, known technically as a "grade crossing;" (3) a junction where trains converge from two or more to a common track, or diverge from

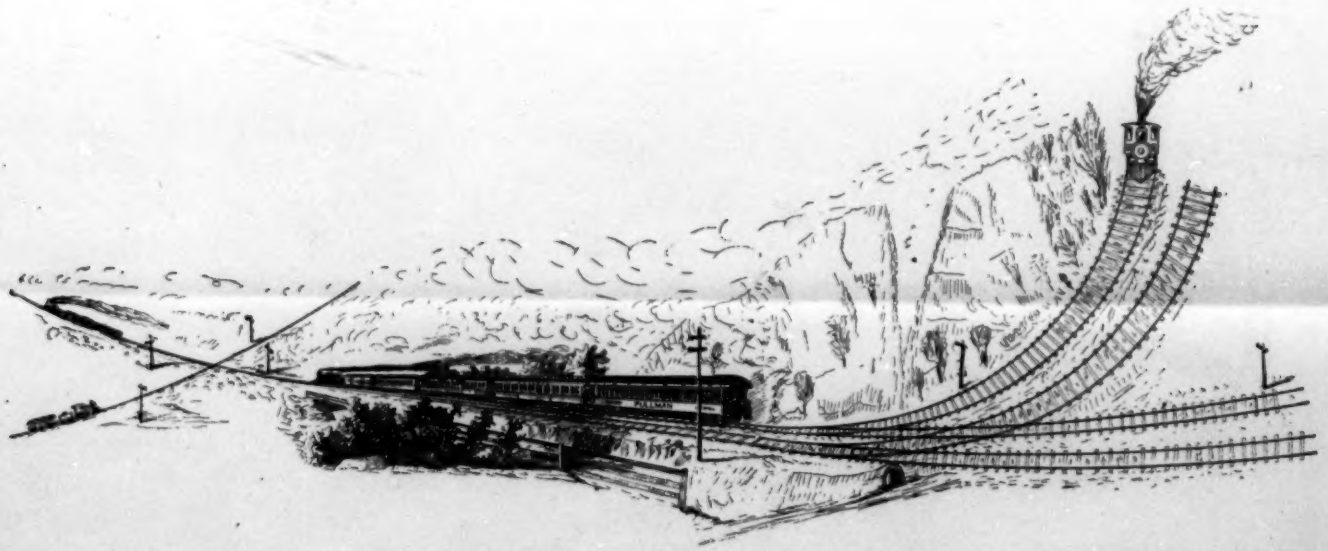


FIG. 1.—Following trains, a grade crossing, and a junction.

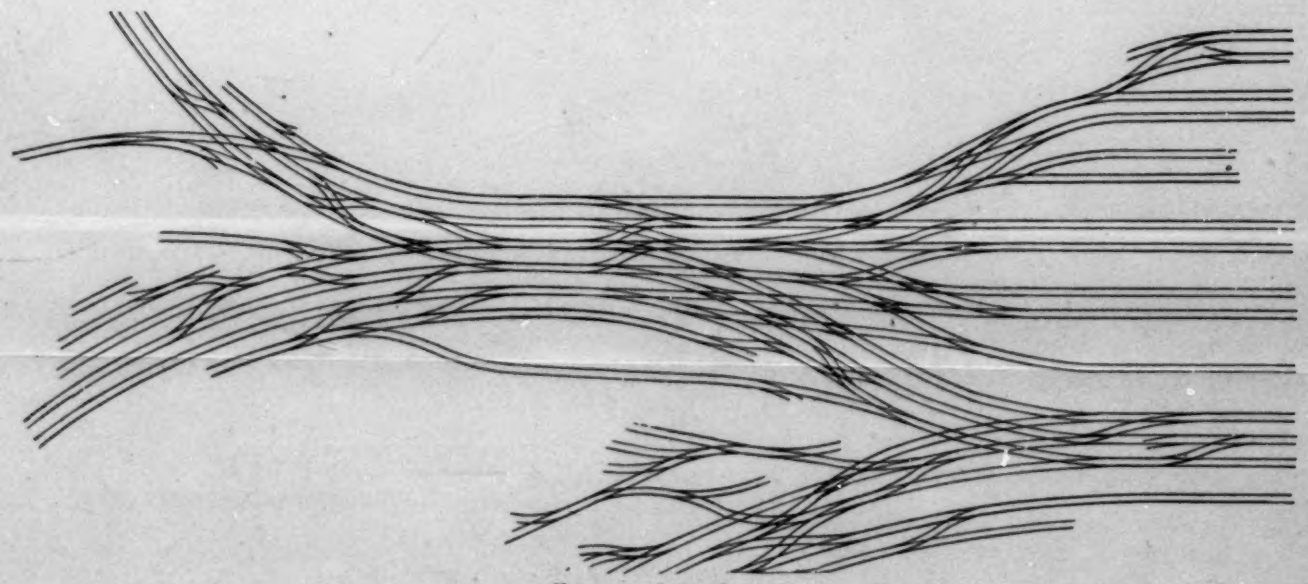


FIG. 2.— A terminus.

FIG. 6.—Early automatic signal.

FIG. 7.—Method of operating automatic signal.

one to two or more tracks; *Fig. 2*, a terminus, where traffic is heavy in both directions over all tracks.

Drawbridges may be classed with No. 2, while the approaches to bridges and tunnels are special cases of No. 3, and these general classes comprise all the points of danger for which fixed signals are necessary.

If, in the case illustrated in *Fig. 1*, there were but one train, fixed signals for the guidance of that train would be unnecessary, but if there are two trains, there is always danger of the second train overtaking and colliding with the first at a stop, be it regular or accidental; and if three or more trains rapidly succeed one another, the danger of rear collision is proportionately greater, and greater is the anxiety, the worry, and the care of those whose duty it is to maintain the safety of the trains.

FIG. 7.—Method of operating automatic signal.

To say, with some people, that railroad owners and officers are either ignorant or careless on the subject of train safety is arrant nonsense, for they themselves ride frequently, their families ride frequently, their friends ride frequently, their reputation is at stake, their money is invested, and who should be more interested than they in guarding a train from accident? They may not always be mechanical or scientific experts, and able to determine at sight the value of a new invention; they may sometimes trust too much to the established reputation of a contrivance long in use, and sufficient for the needs of the past, but perhaps not equal to the greater demands of the present; or there may not be money available to make radical and extensive changes within a short time, though the changes are for other reasons advisable, but to say that these men, who are the most concerned, are not always striving by every reasonable means to make their tracks, their signals, and their trains reliable and efficient, is to talk without reason and without experience. You may be sure that efficient appliances are put in use as soon as the railroad needs are determined and some one has devised the thing to meet them.

When trains began to follow each other in rapid succession, it was thought sufficient to start them out at intervals

of ten minutes, so that by running at uniform speed they would for the distance between stations be safe from collision. But it did not take long to find that slight accidents to the running gear of a train easily caused it to lose six or seven minutes, and the following train was upon it before there was time for warning.

If only the weather were always fair, and if only the tracks were always straight, so that an engine-man could distinctly see a mile ahead, the case would not be so bad, for then a train might always be stopped before it was too late. But every one knows that even in this country, to say nothing of worse ones, there are thirty or forty foggy days in the year, when no one can see a half mile away; and if any one thinks that railroad tracks are straight, he needs but to look out of the rear window of a train leaving this city on the Pennsylvania or the Reading, or to take a ride up the Belvidere or the Lehigh Valley, to have his illusions dispelled.

For safety, it is of course necessary that running trains should be warned of danger in time to stop, which can be done in, say, a half mile. But if two trains pass a signal post within ten minutes of each other and some little thing goes wrong on the forward train, a couple of minutes may easily be lost before the engineer is aware of it, and if then he runs a short distance before he decides to stop, he may be three minutes behind time. The stopping will occupy possibly a minute more and by this time there is only six minutes between the trains. A flagman must then run back a half mile if there is snow or fog, which will probably occupy the six minutes. So that in such a case, which is not at all an uncommon one, the second train could with difficulty be warned and stopped in time.

The accuracy of the statement is unfortunately proven by innumerable rear collisions.

It looks strange to us now that such a system should ever have been adopted, it looks stranger still that it should have continued long in use, and it looks strangest of all that nine-tenths of the railroads of the United States are still run on this plan; but, under the circumstances, it is not at

all strange that only some three months since a serious accident to two express trains occurred on a prominent Eastern road, due to this same cause.

In England, the home of railroad signaling, the change was soon made and there throughout the country, scarcely 100 miles of railroad excepted, running trains are separated not by a time interval, but by a space interval; and are kept apart not so many minutes, but so many miles or fractions of a mile. In this country the Pennsylvania and the Old Colony present examples of railroads making a strong

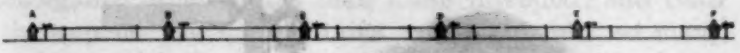


FIG. 3 (a). Signals, Cabins and Telegraph Line of the Block System.

effort to put in force the same system throughout. They have not accomplished it over all their lines, but aim to. The New York Central has about fifteen miles so operated, and the New York, Lake Erie and Western about fifty, while the Wabash, Michigan Central and Canadian Pacific have some distance of single track.

Wherever this system is introduced, signals are erected along the line at somewhat regular distances from each other (*Fig. 3*), the distances varying somewhat, of course, according to the amount of traffic, being three or four miles

FIG. 3 (b). Delayed Trains.

where the traffic is light, and a half or a quarter of a mile where trains follow each other in rapid succession and cannot therefore be kept far apart.

A signal-man, in a little cabin, is placed at each pole, and must not give a safety signal until he has received telegraphic word from the signal-man at the next station ahead that the preceding train has passed out of that section. Then he may admit another train. Thus no two trains are allowed upon the same section or block at the same time.

This is known as the block system, and when rigidly carried out, as the absolute block system, and the only danger

of collision is from disobedience to orders on the part of the signal-man, or from fog coming up or snow coming down in such quantity as to prevent the engine-man from seeing the signal, thus in either case letting him run out of his section, perhaps to collide with a train in the next.

I will show you how in fog or snow the engine-man is warned of the position of the signal when he cannot see it. *Fig. 4* shows a signal post and arm, and, connected with the

FIG. 4. The Railroad Torpedo Machine.

signal-arm, though placed just outside the rail, a little machine containing small torpedoes or large fulminating caps, say one inch in diameter, and quarter of an inch thick, the whole so arranged that when the signal-arm is at danger the torpedo is in position for firing, and would be exploded by the first wheel of a passing train; while when the signal goes to safety, the lowering of the board draws the torpedo out of position, and trains pass without firing it. On a track run by the absolute block

system, the explosion of a torpedo would thus signify a semaphore at danger, the end of a block, and would call for the immediate stoppage of the train.

Other devices have been used to attain the same end, for example rods (*Fig. 5*), automatically set when the signal goes to danger, to catch a rod projecting from the locomotive and sound the whistle or the bell. But the two circumstances which have brought the railroad torpedo machine into prominence are that, being fired by the pressure of the wheel, it requires no rod projecting from the locomotive, which may catch against other things than those intended; and that, as the torpedo machine contains, when full, just so many torpedoes and is fastened by a padlock, it is easy to deter-

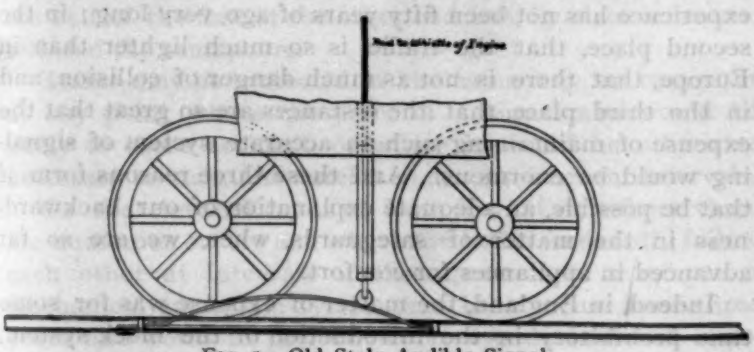


FIG. 5. Old Style Audible Signal.

mine in the case of rear collision whether a careless signalman admitted the train by safety signal to an occupied block, or a careless engine-man ran past a signal at danger.

To guard against the error or disobedience of the signalman, it is now customary in dangerous places, and where the blocks are short, to have the semaphore locked in the danger position by a little bolt, which can be withdrawn only by the action of an electric current sent by the man in the station ahead, and thus prevents the admission of two trains to one block, as long as the engine-man can see the signals and the brakes will stop the train.

These, then, are the points made plain by fifty years' experience in signaling continuous double tracks: that to be safe, trains must be kept apart a certain interval of

space, and not an interval of time; that at all important points the ordinary signals should be reinforced by automatic audible signals, if there is any danger of fog, of driving snow, or of sleepiness on the part of an overworked engine-man, and that ordinary line signals should be controlled by two separate men, since the results of carelessness or error on the part of a signal-man are otherwise unavoidable.

When we try to ascertain why the experience of fifty years is not universally applied, and why in this country most of the railroads separate their trains by a time interval, and so few use the absolute block system or even a permissive block system, we find, in the first place, that the experience has not been fifty years of age, very long; in the second place, that the traffic is so much lighter than in Europe, that there is not as much danger of collision, and in the third place, that the distances are so great that the expense of maintaining such an accurate system of signaling would be enormous. And these three reasons form, if that be possible, an adequate explanation of our backwardness in the matter of safeguards, when we are so far advanced in appliances for comfort.

Indeed, in England, the matter of expense was for some time prohibitory in the introduction of the block system, and there were many attempts to make the working of the block signals automatic (*Fig. 6*), that is, to set some contrivance near the rail at each post, by means of which the passage of a train should set to danger the signal immediately behind it, and as it passed the other end of the block, set the signal there to danger, but throw the first to safety (*Fig. 7*).

The difficulty about all such systems is that the apparatus, no matter how good, is liable to get out of order and to cause serious delay and perhaps accident; that the system is with difficulty applicable to tracks at all complicated, and that the presence of men is always necessary, not only to keep the apparatus in order, but to watch over the signals themselves to see that they work correctly, and over the trains as they pass to detect anything that may be wrong

in them, and to act in emergencies with experienced intelligence.

But there *are* places in which an automatic system of block signals is easily applicable and of the greatest benefit. The signals at curves and at tunnels—in both of which cases it is impossible for the lever-man to see the signals or the trains—and those on any lines where the traffic is very great, should be worked by this plan.

There is in common use for this purpose an electric block system, exactly similar to the one described a moment since, except that it is automatic. The entrance of a train into a tunnel locks at danger the semaphore behind it, and prevents the entrance of another train into the tunnel until the exit of the first at the other end has, by electric means, released the semaphore.

Trains may be protected in the same way on curves or at any point where the error of a signal-man would be likely to cause accident, or where it would be otherwise necessary to maintain watchmen at very frequent intervals.

On the elevated roads of New York City, where there are numerous curves and where the trains frequently follow each other at intervals of three-quarters of a minute, a mechanical automatic system has been in use some three years, and works to perfection. It was devised and introduced by the road-master, Mr. Black, and of course has the benefit of his care; but I am informed that the cost of maintenance is almost nothing, being only the oiling which is necessary for the moving parts. The reputation of the system, for reliability and efficiency, is so good that the Kings County elevated railway, in Brooklyn, is now introducing it on its line of five miles of double track. It is also used on Staten Island Rapid Transit Road, on the Brooklyn Bridge and in some other places; and if the reports from the managers of these roads, which I have seen, mean anything, they mean that the automatic block signal there in use is practically perfect for short blocks, and moderate speeds.

There is one point, however, about these automatic block systems always to be kept in view, which is that the

couplings between cars frequently break or become detached and the train parts in the middle, so that the first half of the train may be safely off the block or out of the tunnel while the second part is not. And since the second train, if it collides with the first, will hit the rear of that train, it is the whole of the first train and not the locomotive alone which must be off the block. Any automatic system, therefore, which signals only the passage of the first end of the train and not the passage of the whole train, is of

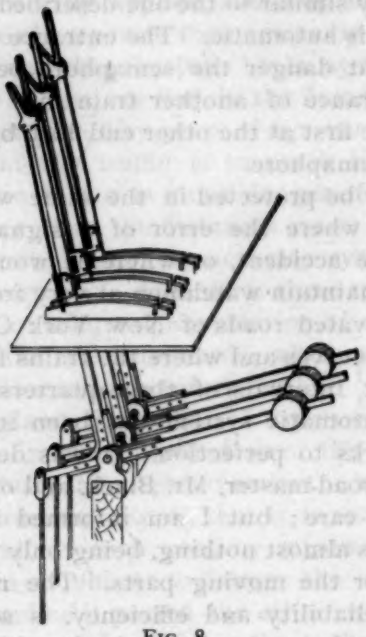


FIG. 8.

use only where trains never break in two, and is dangerous where there is any liability of such an accident.

But these subjects are now receiving more attention and there is no doubt that the automatic block system in some of its electrical or mechanical forms, is the solution of the matter of expense in connection with the block system.

Coming to our second general case of signaling, for trains which cross each others' tracks on grade, we find the added difficulty of preventing trains on the two lines, which are at

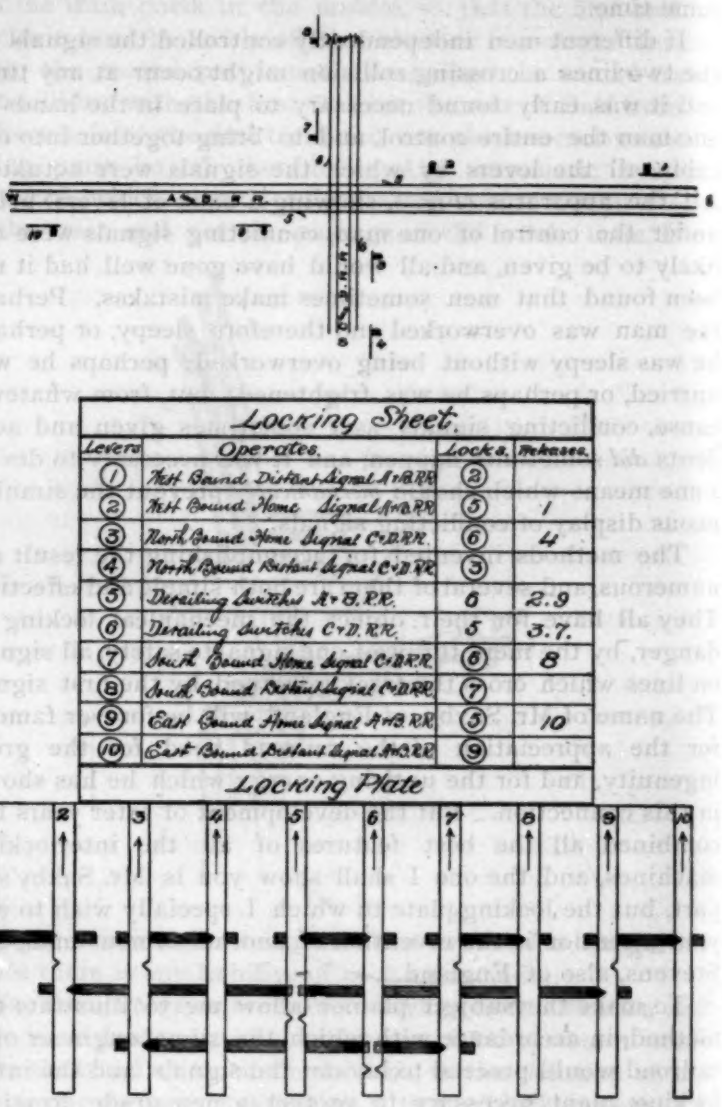
an angle to each other, approaching the crossing at the same time.

If different men independently controlled the signals on the two lines a crossing collision might occur at any time, and it was early found necessary to place in the hands of one man the entire control, and to bring together into one cabin all the levers by which the signals were actuated. All the apparatus (*Fig. 8*, showing a bank of levers) being under the control of one man, conflicting signals were not likely to be given, and all would have gone well had it not been found that men sometimes make mistakes. Perhaps the man was overworked and therefore sleepy, or perhaps he was sleepy without being overworked; perhaps he was hurried, or perhaps he was frightened; but, from whatever cause, conflicting signals *were* sometimes given and accidents *did* sometimes happen, and it was necessary to devise some means which should *mechanically* prevent the simultaneous display of conflicting signals.

The methods invented for accomplishing the result are numerous, and several of them are both simple and effective. They all have for their object the mechanical locking at danger, by the mere throw of one signal to safety, all signals on lines which cross the track governed by the first signal. The name of Mr. Saxby, of England, will be forever famous for the appreciation of the railroad need, for the great ingenuity, and for the untiring energy which he has shown in this connection. But the development of later years has combined all the best features of all the interlocking machines, and the one I shall show you is Mr. Saxby's in part, but the locking-plate to which I specially wish to call your attention is the invention of another famous man, Mr. Stevens, also of England.

To make the subject plainer allow me to illustrate the method, in accordance with which the signal-engineer of a railroad would proceed to lay out the signals, and the interlocking plant necessary to protect a new grade crossing. *Fig. 9* shows the number and position of the signals ordinarily considered sufficient. Having decided upon these, the engineer would put down in tabular form the names or

numbers of signals which would conflict with each other, and



Locking Sheet.

Levers	Operates.	Locks.	Releases.
1	West Bound Distant Signal A & B R.R.	2	
2	West Bound Home Signal A & B R.R.	5	1
3	North Bound Home Signal C & D R.R.	6	4
4	North Bound Distant Signal C & D R.R.	3	
5	Derailing Switches A & B R.R.	6	2.9
6	Derailing Switches C & D R.R.	5	3.7.
7	South Bound Home Signal C & D R.R.	8	8
8	South Bound Distant Signal C & D R.R.	7	
9	East Bound Home Signal A & B R.R.	5	10
10	East Bound Distant Signal A & B R.R.	9	

Locking Plate

FIG. 9.

the levers for which, therefore, must be interlocked. Such a table is called a locking-sheet and for the extremely simple

case in question, would have somewhat the appearance shown.

I am taking a case to illustrate the principle of the interlocking machine, and nothing else. It is not presumed that there is any interlocking outside the tower, and it is not presumed that there are used any of the recent inventions

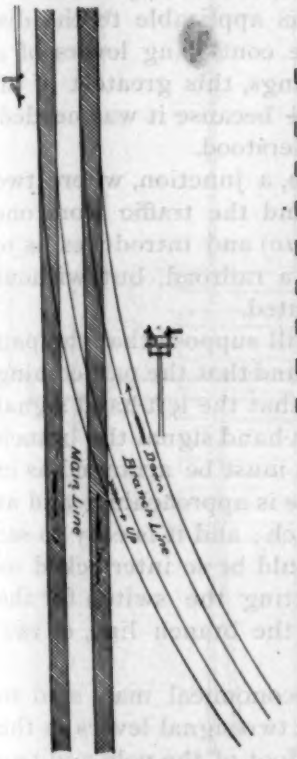


FIG. 10. Junction, with Signals.

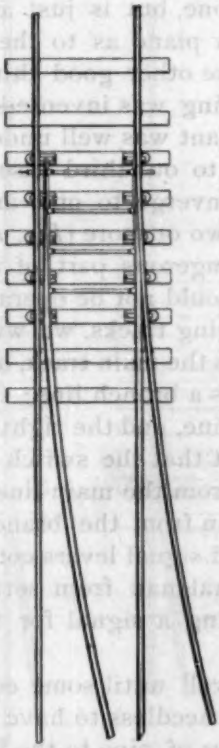


FIG. 11. Switch Right for Main Line.

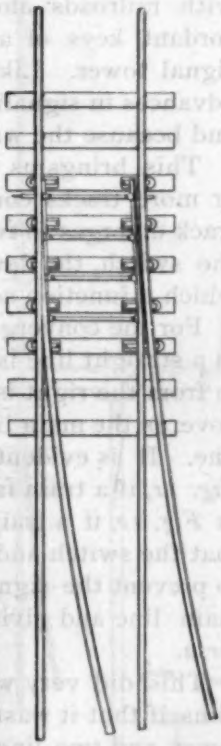


FIG. 12. Switch Right for Branch Line.

for reducing the number of levers necessary to operate the signals and the derailing switches. It is planned in the good old-fashioned way, and there are necessary ten levers. An engineer of to-day would add several safety devices and would still be able to operate the whole station with six levers.

Having decided upon the character of his locking-sheet, the engineer would proceed to design the locking-plate, which is the important part of the machine to carry this out. *Fig. 9* shows also the locking-plate necessary for this crossing, and is best discussed upon the screen.

These, then, are the first principles of interlocking, and it is easily seen that the system is not necessarily connected with railroads alone, but is just as applicable to the discordant keys of a piano as to the conflicting levers of a signal tower. Like other good things, this greatest of all advances in signaling was invented because it was needed, and because the want was well understood.

This brings us to our third case, a junction, where two or more tracks converge to one, and the traffic from one track diverges to two or more (*Fig. 10*) and introduces us to the switch, the dangerous part of a railroad, but without which a junction could not be operated.

For the converging tracks, we will suppose that the pair in a straight line is the main track, and that the pair coming in from the right is a branch line; that the left-hand signal governs the main line, and the right-hand signal the branch line. It is evident that the switch must be arranged as in *Fig. 11*, if a train from the main line is approaching, and as in *Fig. 12*, if a train from the branch; and it is easy to see that the switch and signal levers could be so interlocked as to prevent the signal-man from setting the switch for the main line and giving a signal for the branch line, or *vice-versa*.

This did very well until some economical man said to himself that it was needless to have two signal levers in the tower and two lines of pipe to the foot of the pole and two sets of carriers for the pipe, all for two signals so near together, and both of which must never be cleared at the same time, so he devised a little apparatus of the most simple but most efficient kind, called now a selector, which does away with one lever and one line of pipe, and enables the remaining lever to operate the two signals, one at a time, and insures that it shall be the proper one. Hence its name, selector, because it *selects* the proper signal. I

must show you its construction, because it is so simple, so efficient and so ingenious. It has grown up through many

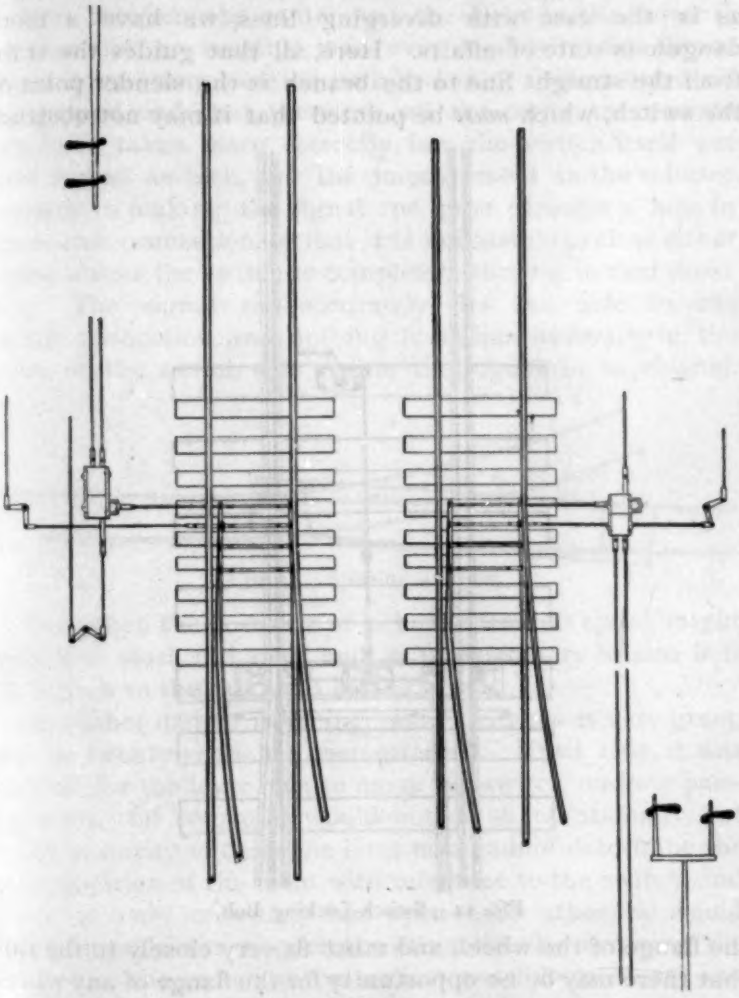


FIG. 13. The Selector.

stages, of which I show you the latest (*Fig. 13*) on the screen.

Switches to operate conveying lines are known as trail-

ing-point switches, and they are operated with safety by the foregoing appliances.

But if we approach the switch from the other direction, as is the case with diverging lines, we have a more dangerous state of affairs. Here, all that guides the train from the straight line to the branch is the slender point of the switch, which *must* be pointed that it may not obstruct

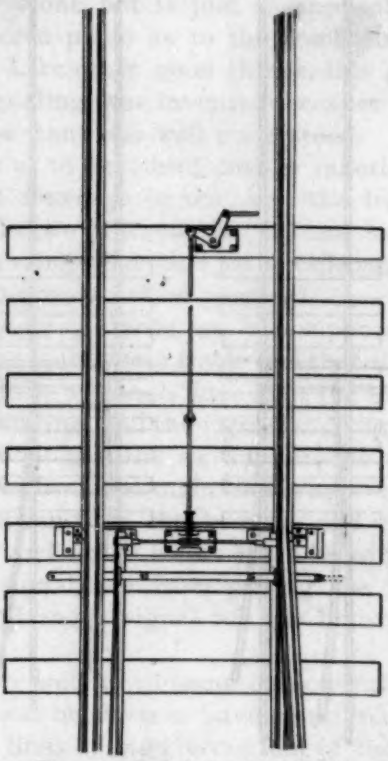


FIG. 14. Switch-Locking Bolt.

the flange of the wheel, and must fit very closely to the rail that there may be no opportunity for the flange of any wheel of the train to get between the switch point and the stock rail. This is the dangerous point about the switch and the one which has caused more anxiety than all the others together. And this has led to the most valuable of all developments in, and applications of, the selector.

The difficulty consists in the absolute necessity of having the switch point in contact with the stock rail before the safety signal is given, and the possibility that the pipe connection between the switch and the lever in the tower (I say pipe, for no sensible man ever used wire for throwing switches) may have become broken or disconnected on the ground, and that, therefore, all the tower movements may have taken place correctly, but the switch itself not have moved an inch, and the improvement in the selector consists in making the signal rod pass through a hole in the switch connection, so that it is impossible to clear either signal unless the switch is completely thrown in that direction. The signal rod accurately fits the hole in the switch connection, and nothing less than accuracy in the throw of the switch will enable the signal to be cleared.

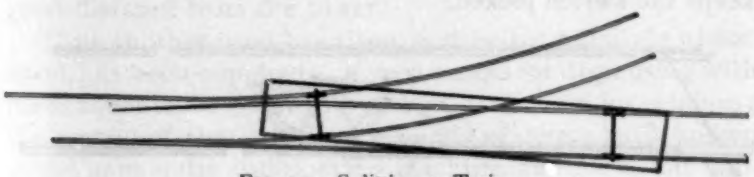


FIG. 15. Splitting a Train.

Even then the pressure of a heavy train at speed might push the stock rail over, and it is customary to also bolt the switch to the rail as in *Fig. 14.*

One other danger in facing point switches is very great, and for twenty years has been guarded. Until 1867, it was possible for the lever-man to move the switch under a passing train. Of course he would not do so intentionally, but in the majority of cases the lever-man cannot determine the exact position of the train with reference to the switch, and if trains were crowding fast upon each other he would naturally endeavor to open the other line by changing the position of the switch at the earliest possible moment; and in his haste he would sometimes, before the train was entirely past, throw the first signal to danger, unlock the switch and reverse its position, thus sending the remainder of the train on the wrong line. Of course the results were disastrous. This is known as "splitting" the train, and it

sometimes went so far as to send the front wheels of a car on one track and the rear wheels on the other (*Fig. 15*). If only it were *mechanically* impossible to unlock or reverse the switch during the passage of a train this most serious danger would no longer exist, and the aim has been accomplished by the invention of what is now known as the detector-bar, so called from its detecting the presence of a train and preventing the intentional movement of the switch (*Fig. 16*). It is a long light bar of iron parallel to the rail, outside, and so connected with the switch that the switch cannot be moved until the bar is raised, but placed so close to the rail that the bar cannot be raised while a wheel is upon that part of the track. The bar is made longer than the greatest distance between any two consecutive wheels of a train, and, therefore, is kept down while the train is passing, and itself keeps the switch locked.

FIG. 16. The Detector-bar.

These two modern devices are the safeguards of the switch. The selector insures the impossibility of giving a wrong signal, and the impossibility of giving any signal until the switch is safely thrown in one direction or the other, and securely locks the switch while either signal is at safety; and the detector bar prevents the switch from being intentionally moved under a passing train.

Our fourth case, the terminus, refers, of course, to a city station, or a wharf, or some place of this kind where trains come in and unload, remain some time, and back out; and includes tracks for incoming trains, numerous sidings, where cars may rest until they are again needed, and numerous crossovers for the passage of incoming trains to outgoing tracks, and to and from the sidings.

Any case of this kind however, no matter how complicated, needs, for its operation and protection, only the block

system, the interlocking machine and the switch safeguards. I show you illustrations of some such arrangements of tracks and you may judge of the care necessary in designing the apparatus for protection and in daily management.

In some large yards the switch and signal levers are so numerous, frequently amounting to seventy or eighty and sometimes reaching 150 (*Fig. 17*), that no one man could manage them rapidly enough, and if two or more men are put in simultaneous charge, many of the benefits of the interlocking machine, in expeditious working, are again lost, for the very reason that the yard is no longer worked by one man, but by three or four men who must study each others' doings. And in addition, the mere manual labor of moving so many levers, switches and signals is found to be excessive, if the traffic is at all heavy and the switches at any great distance from the tower.

Thus another need has risen, and being definitely understood, has been supplied. A new means for dispensing with the manual labor entailed by large yards, and for retaining the control of the yard in the hands of one man is known as the pneumatic interlocking machine, and for it the railroad world is indebted to the man to whom it already owes so much, Mr. George Westinghouse, Jr.

In this machine, lines of small pipe run to all switches and signals; but these lines, instead of being themselves movable, are filled with liquid, and so connected at the tower that the operator may force the liquid, and indirectly the switch or the signal, in one direction or the other, by turning a little valve, and when the valves are interlocked conflicting signals cannot be given.

Pneumatic and hydraulic methods of operating distant switches and signals are not new, but they are extremely expensive when applied to small towers, or to one or two distant switches of a large tower, and the pneumatic or hydraulic interlocking machine finds its place not in a station requiring ten or a dozen levers, but in a station of sixty or seventy or more.

In these yards the signals are very numerous, as will be supposed. And if we have four tracks converging to one,

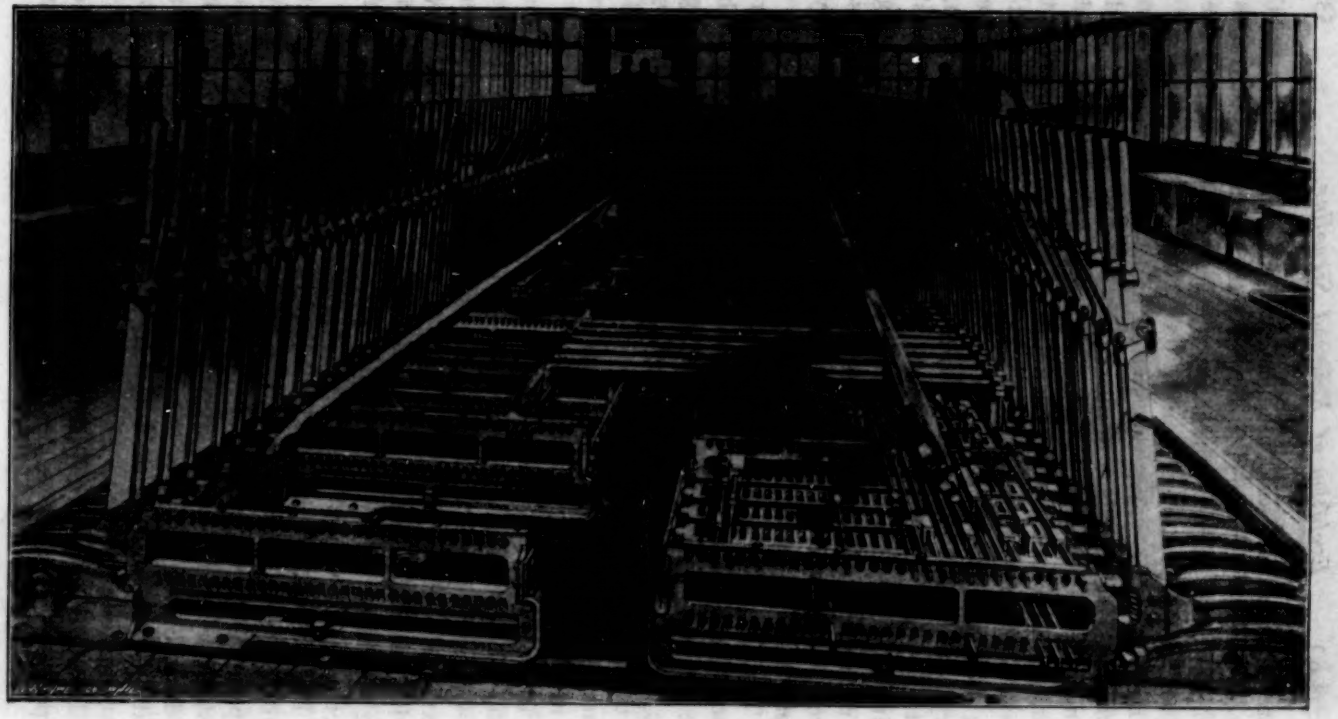


FIG. 17. Bank of Levers at a London (Eng.) Terminus.

or the traffic from one track diverging to four, we must have, in either case, four signals; and since this is likely to be repeated several times in a large yard, the signals become so numerous as to be with difficulty distinguishable as related to particular tracks; and of late it has become the custom to put on one pole, not four semaphores, but one semaphore and four disks, numbered in succession 1, 2, 3, 4, one of which comes down each time the semaphore is dropped, and shows which track is open for the train.

This all tends to simplicity, in that the semaphores are one-fourth as numerous, the lamps are one-fourth as numerous, the amount of oil burned is one-fourth as great, and the amount of work to be done in taking down and cleaning and putting up lamps is one-fourth as great. This last is of great importance, for the condition most undesirable in any mechanical contrivance is that it should require continuous supervision on the part of an experienced attendant.

But on the heels of this great improvement, suggested by some wise man, comes another new thing suggested by some unwise man, an attempt to introduce a new kind of semaphore operated by a weight like that of a clock, which runs down and therefore requires to be wound up, say every twentieth time the semaphore is moved. The idea of a man with a great key, running around a railroad yard, winding up semaphores, and the idea of a railroad putting in signals whose very operation, by day or by night, depends upon the regularity of this performance is most ridiculous; and to make it worse, this simple and reliable and economical signal is sold for the small price of about four times the cost of an ordinary one, which will take care of itself.

This leaves but our last topic, the *form* of the signal.

The track was originally considered to be "clear" if no signal was displayed, while the exhibition of a disk or other board signified "danger" (*Fig. 18*). But accidents sometimes happened to these danger signals after they were properly set, obscuring or perhaps destroying them, their absence thus acting as a safety signal and luring a train on to danger; and this caused the promulgation of a

FIG. 17. Bank of Levers at a London (Eng.) Terminus.

rule that engine-men should not only not see "danger" signals, but should receive definite "all clear" signals at these stated fixed points before passing them (*Fig. 19*); and this, in turn, led to the quest, ever to be continued, for the signal whose changes should best give alternate intimations of danger and of safety.

All railroad men agree upon the conditions of efficiency required in a fixed signal.

(1) It should be distinct.

(2) It should be distinctive.

(3) Its changes should be marked.

(4) Its day and night appearances should not be contradictory.

By being distinct is understood that the engine-man should find no difficulty in seeing the signal at any reason-

FIG. 18. Early Danger Signals.

able distance by day or by night. By being distinctive is meant that it should be impossible, or nearly so, for the engine-man to mistake the signal for any other object along the track. By the third condition is meant that a glance should decide whether the signal is at "danger" or at "safety;" while the fourth condition, that the day and night appearances of the signal shall not be contradictory, needs no explanation.

None of the signals that I have just shewn upon the screen answered the above conditions. And so, in 1841, Mr. Gregory proposed the semaphore, an elongated board, whose horizontal position should say to an engine-man, "Stop," and whose position, when inclined to the post at any angle, should say, "Proceed." This signal, whose use has since

grown general and whose value each succeeding year confirms, is now the universal choice of railroad men as a daylight fixed signal, not because it is faultless, but because more nearly than any other it answers the conditions of being distinct—for it is easily seen; distinctive—for it resembles nothing else along the track, and marked, *by its position*, in its changes from danger to safety.

The early fixed signal for night use was a lamp, in front of which was placed a red glass, so that for danger at night the engine-man saw, at the appointed place, a red light, while for safety the red glass was removed and he saw an

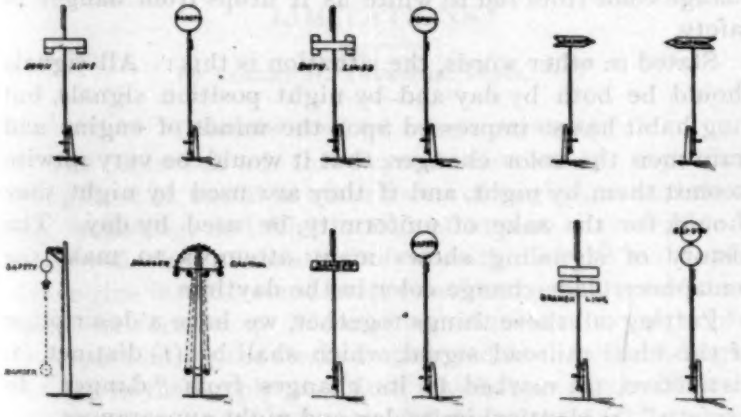


FIG. 19. Early Signals Showing Danger and Safety.

ordinary lamp light, by railroad courtesy called white. And this form of night signal is still in almost general use.

The situation in the matter of signals has undergone so little change until within a year that it may be concisely stated as follows: The daylight fixed signal has been one changing in position, but not in color, while the night fixed signal has been one changing in color, but not in position. Everybody has known all along that it was desirable to add position changes to the color changes of the night signal, because the railroad red light is just like any other stationary red light, and the railroad white light is just like any other stationary white light, which is another way of saying that the railroad signal light can with difficulty be

distinguished from other lights along the track, which is another way of saying that the railroad night signal is not distinctive; and as far back as 1866, I find recorded attempts at illuminating the semaphore blade for night use, making it therefore different from other lights and a distinctive railroad signal; but the subject has never received the general attention of railroad men until within the last two years.

Everybody has known, too, that uniformity in day and night signaling is desirable, and that since all night signals change color from red to white, the day signal should also change color from red to white as it drops from danger to safety.

Stated in other words, the situation is this: All signals should be both by day and by night position signals, but long habit has so impressed upon the minds of engine and train men the color changes, that it would be very unwise to omit them by night, and if they are used by night they should, for the sake of uniformity, be used by day. The history of signaling shows many attempts to make the semaphore blade change color in the daytime.

Putting all these things together, we have a description of the ideal railroad signal, which shall be (1) distinct, (2) distinctive, (3) marked in its changes from "danger" to "safety," (4) identical in its day and night appearances.

It must be a semaphore, (1) changing position by day and by night; (2) changing color by day and by night, and giving us as a result a board always horizontal and red for "danger," always horizontal and green for "caution," always at an angle and white for "all clear."

I show you on the screen the parabolic semaphore, the only signal which has all the requirements just mentioned.

Our brief review has omitted all appliances which have not tended directly to form our present methods of signaling, and in all things we have discussed merely first principles; but we have learned the origin and object of the block system, of the interlocking machine, of the switch safeguards, and of the present form of signal.

I have to make my acknowledgments to various signal

companies and to the Lehigh Valley and Pennsylvania Railroads for their courtesy in bringing my information approximately to date.

The paper was not written for the instruction of historians or experts in signaling, but if every one here is now convinced that he is sufficiently well informed upon the subject to become without further study a signal-engineer, the hour has not been lost.

PHILOSOPHY OF THE MULTI-CYLINDER, OR COMPOUND, ENGINE; ITS THEORY AND ITS LIMITATIONS.*

By ROBERT H. THURSTON, Ithaca, N. Y.

(*Continued from vol. cxxviii, page 477.*)

The influence of the several economical expedients recognized as useful in other forms of engine, as superheating, jacketing, and high speed of engine, may readily be perceived when the method of operation of the multi-cylinder engine is understood in its relations to heat-transfer and heat-transformation. We may consider them in their order.

Superheating the steam transferred from boiler to engine results in the supply of a fluid which may surrender a certain portion of heat, measured by the product of its specific heat as a gas into the range of superheating and into its weight, to the metal of the working cylinder without the production of initial condensation. If this quantity is equal to or greater than the loss of heat during expansion and exhaust, there will be no initial condensation, and the waste from the high-pressure cylinder will be nearly that due to the passage of a gas through it under similar conditions of temperature and expansion, a comparatively small quantity, since any substance in the gaseous state possesses low conductivity and slight power of absorption and storage of heat. Should the superheating be in excess of

* Presented at the Twentieth Meeting of the American Society of Mechanical Engineers, held in New York, November, 1889. Revised by the author for publication in the JOURNAL, and printed by permission from advance sheets of the Society's *Transactions*.

this amount, the steam will not begin to condense until a later period, perhaps not at all, the only demand being now for heat to supply the amount required to keep the steam dry and saturated while expanding and doing work. If the superheating be less than the first mentioned quantity, initial condensation will be reduced but not entirely prevented. It is probably never the fact, in practice, that it is possible to secure, safely and economically, so much superheating as is needed to keep the stem dry throughout the stroke.* In any case, the quantity of heat represented by the superheating will be a gauge of the amelioration of wastes by internal transfer of heat in every cylinder of the series. The steam leaving the high-pressure cylinder will be to that extent dryer than it would otherwise be; and this will be true of the succeeding cylinder or cylinders.

Were there no other disappearance of heat than that due to cylinder condensation, superheating at the first of the series would give superheating at each of the others. In so far as condensation doing work, such as was pointed out by Rankine and Clausius, takes effect, and so far as other wastes by transfer without transformation occur, to that extent will the gain, as observed in successive passages from cylinder to cylinder, be reduced, though the improvement of the working conditions above asserted will be none the less real. Each cylinder will have wetter steam than the preceding, in proportion as the condensation doing work and the losses by conduction and radiation increase, as a total, cylinder by cylinder. Superheating at the high-pressure cylinder will produce a favorable effect all through the series, including the low-pressure cylinder. Cylinder condensation will, nevertheless, cumulatively increase through the series, in consequence of the fact that the wetter the steam entering any one cylinder the more the condensation and the wetter that leaving it, both by this initial increase of humidity and by the additional moisture coming from the Rankine and Clausius phenomenon, and from the loss

* In one case reported to the writer an initial superheating of 500° F. was required to give 50° F. superheating at exhaust; 100° F. has usually been considered a practical maximum superheat.

by transfer to surrounding bodies. This last action will, however, be the less observable and the less important in its effect as the moisture of the entering steam and the magnitude of the waste by initial condensation become greater. The more nearly the total proportion of water in the mixture approaches one-half, the more nearly does this phenomenon become a vanishing quantity. It may probably be neglected entirely in the computation of efficiencies for a large proportion of the engines in use, without introducing sensible error, and very probably may be neglected in all cases without invalidating conclusions reached ignoring it. On the other hand, superheating is not likely ever to produce much effect upon this action. Could we superheat safely and satisfactorily to the extent of doubling the absolute temperature of the steam at entrance into the engine, we might have a "superheated steam-engine," but this is not yet practicable, and, until it becomes so, it is not likely that the best engines will entirely satisfy our theory in this respect.

Steam jacketing, the expedient devised by James Watt for the very purpose of reducing wastes by internal condensation, a phenomenon of which he was the discoverer, is a method of approximately "keeping the cylinder as hot as the steam which enters it," as Watt put it, in order that no such chilling of the entering steam may occur. We are interested in the answer to the question: To what extent and in what manner is the jacket advantageous in the compound or multi-cylinder engine? Authorities disagree, even where they have themselves had large practical experience. It is sometimes advised to jacket only the high-pressure cylinder; sometimes to jacket only the low-pressure cylinder, and sometimes to jacket the whole series, whether one, two or three, or more. The philosophy of the multi-cylinder engine, as above outlined, would obviously indicate that, to secure maximum good effect, assuming the jacket on the whole desirable at all, the best system is the latter, and that, since the waste of the engine is measured by the waste of its most wasteful member, to omit the jacket from any one cylinder insures

that the aggregate loss of heat in the whole engine will be increased by just the amount by which waste is increased in that one cylinder by such omission.

The resulting effect, in detail, is evidently the following: Assume the intermediate cylinder to be unjacketed. That cylinder being exposed to a wider range of heating and cooling action as it alternately takes steam and exhausts it, is subject to a greater waste by internal condensation than either of the others; it thus discharges into the next cylinder an equal quantity of heat and steam, but it does less work than it would have otherwise done, and to that extent produces decreased efficiency. Assume the high-pressure cylinder unjacketed, it demands more steam from the boiler, as it condenses a larger proportion of that entering by this process of initial liquefaction; it is thus itself more wasteful and furthermore transmits to the succeeding cylinders a larger quantity, and therefore a more uneconomical apportionment of steam than it would otherwise have released. In proportion as its own efficiency is thus reduced, it reduces the economical working of the whole; and, in proportion as the steam rejected from it is a less economical storehouse of heat for use in the other cylinders, they are in turn rendered less efficient. The low-pressure cylinder being left unjacketed, it becomes more wasteful in proportion to the increased initial condensation thus permitted, and the whole system is again, to that extent, given impaired efficiency. In neither case, however, is the efficiency of the engine, as a whole, impaired nearly as seriously as in the case of the simple engine. The increased loss is mainly confined to the single cylinder left unjacketed. It is readily seen, however, that, to secure maximum efficiency, it is as essential to jacket the cylinders of the compounded engine as that of the simple engine. The question which actually arises in practice, for the designing engineer, is whether it will *pay* to jacket at all or not. It can at once be seen that it is not as important, in a financial sense, that the multi-cylinder engine be jacketed as it is to jacket a simple engine of similar range of expansion. The value of the waste due to omission of the jacket is less as

the number of cylinders is the greater. It is also seen that those conditions which may make it undesirable, as a matter of finance, to jacket the simple cylinder, make it still less desirable in the compound or multi-cylinder engine. As piston speeds are increased, for example, the necessity of the jacket decreases, and the limit at which it will pay to dispense with it is sooner reached in the multi-cylinder than in the single-cylinder engine. It is this principle which justifies the now not uncommon practice of omitting jackets from marine engines which are driven up to 1,000 feet a minute; while pumping engines, in which the speed is always very low, must always be jacketed, if high duty is demanded.

High engine-speed, the most modern device for reducing internal wastes, as well as of decreasing costs of engine construction and weights of machine, is evidently a matter of less serious importance as the number of cylinders is increased, yet it is equally evident that, to secure maximum efficiency, it is essential that the time of exposure to the action of the wasteful influences in any one cylinder be made a minimum. At modern and customary speeds of piston and of rotation, the value of the other expedients for improving performance is much less than formerly; but all are to be adopted where it is hoped to secure such high efficiency as is coming to be demanded of the designing and constructing engineer. The advantage of further progress in this direction, now that piston speeds of $V = 500\sqrt[4]{S}$ and a velocity of rotation equal to $R = 250\ S^{\frac{2}{3}}$ and upward are becoming usual, does not seem likely to be great; and, except where superheated or thoroughly dry steam can be absolutely insured at all times, the risks attending increased speeds seem also likely to retard this advance. So long as the advantages of further gain in this direction are safely attainable for the simple engine, they are still desirable and attainable in the multi-cylinder machine.

Non-conducting cylinders, such as were partly secured by Smeaton by the use of his wood-lined pistons and heads, and such as have since been sought by Emery and others; such as were shown to be needed by Watt, and later more

conclusively by Rankine and his successors; would do away with the necessity of compounding on the ground of thermodynamic gain; but would leave the advantages of the multi-cylinder engine, on the score of better division of stresses and work, unaffected. What may be done in this direction, it is as yet impossible to judge, but it is not likely that the device of Smeaton can be made successful at modern temperatures and pressures, or in presence of superheating; the plan of Emery of using glass, enamel or other superficial covering of the exposed surfaces has not yet given promise of success, and nothing as yet tried seems to give promise of meeting the requirements of the case.*

The value of even an approximately non-conducting covering of such nature would be considerable for the compound engine, and very great for the simple engine, especially for the smaller sizes in which the proportion of exposed surface is comparatively large. It is not too much to expect that some inventor may yet appear to make this, the most imperative of all needed improvements of the steam-engine of whatever type. It would render the engineer independent of all special expedients for reducing wastes internally and for thus increasing efficiency.

Clearances are usually greater in the multi-cylinder than in the simple engine; but it is at once seen that the loss by clearance and the rejected steam thus utilized in any one cylinder goes to fill the clearances of the next, and thus the loss by this method of waste is divided by the number of cylinders, as in the case of other losses. It remains advisable to reduce the dead-spaces as much as is practicable in the compounded engine; but the importance of this matter is less than in the case of the simple engine. Thus the adoption of multi-cylinder engine reduces wastes of every kind, except those coming of increased radiation from the exterior; where the total area is, as is commonly the fact,

* The writer has recently secured an invention, devised by himself, consisting in the solution of the exposed metal surfaces, leaving the carbon of the casting to form a layer resembling vulcanized rubber, which is to be saturated by drying oils, solutions of gum or other non-conductor, the covering so formed being integral with the cylinder-head or other part.

increased, and of the friction of the engine when the number of cylinders exceeds that giving a minimum. These are, however, minor wastes.

The number of sub-divisions of expansion and the number of cylinders to be introduced in series is finally settled by financial considerations. The fact that the loss by internal wastes is measured by that of one cylinder indicates that, as a matter of economy of heat, simply, there is no natural limit to the number, except that the losses by external conduction and radiation may finally more than compensate the gain by further complication. This principle is easily shown, analytically, thus:

The work performed is proportional to the quantity $I + \log r$, and the cost of that work is proportional to the quantity $I + a\, r^{\frac{1}{mn}}$, since the expansion in one cylinder is the nth root of the total ratio of expansion for the series; m is the index determined by the rate and method of variation of the cylinder condensation with variation of the ratio of expansion, and which is not far from $m = 2$; and a is a coefficient shown by Gately and Kletsch to be about 0·2. The cost of power, measured in terms of steam expended thermodynamically and by internal wastes, is a minimum when the quotient of the two expressions,

$$\frac{1 + \log r}{I + a\, r^{\frac{1}{mn}}},$$

above is a minimum; this is a minimum when the denominator is a maximum; and this is a maximum when the second term is a minimum, or when the value of n increases without limit.

The question which the engineer must solve is this: How many cylinders will it pay to introduce? No general solution of the problem can be given; but it is easily solved by computation for each case as it arises. The considerations involved are the following: It may be taken as the result of general experience, in good practice, that under the best customary conditions of operation a good simple engine, working at high pressure, condensing, and at the

best ratio of expansion for maximum engine efficiency, may be fairly expected to give as good a result as two pounds of fuel of satisfactory quality per horse-power and per hour. Under similar favorable conditions we may, with equal likelihood, anticipate a probability that we may obtain better work with multi-cylinder engines in somewhere about the following proportion:

Engine.	*Consumption.*	*Gain, Total.*	*Gain, Difference.*
Simple, one-cylinder, ...	2 lbs.	. . .	. . .
Compound (double expansion), . .	1·6	20 p.c.	20 p.c.
Triple expansion, ...	1·4	30	10
Quadruple expansion, ...	1·25	40	10
Quintuple expansion, ...	1·1	45	10

The first three cases are based upon what is probably ample experience; the last two are obtained by inference from the rate of progression thus established, and upon the principle above enunciated, that the loss is reduced in proportion, approximately, to the number of cylinders in series. The probable cost of adding one and another cylinder to any given type is easily ascertained by the engineer; he knows the cost of fuel and oil; the value of capital is as easily ascertained; and he can then readily determine whether the gain fairly to be anticipated is sufficient to compensate the cost of its acquirement and to give a fair margin of profit.

Another important inference from what has preceded is that the question of use of one or another type of multi-cylinder engine is not primarily settled by the magnitude of the *steam pressure* to be adopted; although it is well settled by experience and by the financial aspect of the question, as just indicated, that it will not pay to compound a machine working at very low pressures; nor to adopt a third cylinder until the pressure approaches, perhaps four or five atmospheres, the advisability of adding cylinder after cylinder being measured by the rise in pressure, at the rate of not more than one cylinder for each four or five atmospheres pressure. Whatever the pressure, however, the compounding will divide the total thermal loss by internal wastes, approximately, by the number in series; but it does not at

all follow that the efficiency of engine or the commercial efficiency will be reduced in similar ratio. On the contrary, it will never pay to carry the complication as far as the study of the ideal case would dictate. The discrepancy will be found to be the greater as the real engine the more closely approaches ideal perfection, the simple engine becoming the more desirable type as the efficiency of it and of each of the several elements of the compound engine becomes greater.

As respects size, it is now easily seen that the gain by compounding is, so far as the considerations here studied are concerned, at least, likely to prove even more marked with small than with large engines; although it may not be, commercially, as desirable to adopt this complication. As the wastes are invariably, under similar working conditions, greater as size decreases, the desirability of reducing the magnitude of those losses would seem likely ordinarily to be made the greater, also, as size of engine diminishes. With equally dry steam from the boiler, the moisture in the steam and the losses by internal condensation are the larger as the power supplied and the magnitude of the engine furnishing it become less. That experience is showing this to be the fact is evidenced by the steady progress made by builders of small engines in the introduction of the compound engine into the market. In the case of the adaptation of this system to small engines, the effect of cylinder condensation remains in each cylinder, well marked, ordinarily, as is seen in the hitherto unnoticed effect observable where such small engines are constructed of the Wolff type, and the first effect of the cooling action of the metal upon the entering steam is shown by the sudden drop of pressure between the two cylinders, at the moment of opening communication, the fall being like that seen when exhaust occurs into the atmosphere from a high terminal expansion, and amounting, often, to several pounds.*

Problems relating to the relative efficiency of the single

* This has been noticed and provided for by the designers of the familiar type of single-acting compound.

cylinder and the various classes of multi-cylinder engine may be readily solved, assuming the above enunciated principles to be applicable, by first computing the efficiency of the representative ideal engine, and then ascertaining the wastes, of heat, of power and of work, of the several cylinders and of each engine as a whole. Obviously, the computation of the figures for the ideal engine is precisely the same, whether, in either case, the system is simple or compound. The wastes, however, vary with each type and with every size and proportion of engine. If, as is now possible, we may ascertain the approximate, if not exact, measure of every waste for each cylinder and for each engine, whatever its type, it is perfectly practicable to determine the relative merits of each, and the probable efficiency and consumption of heat, of steam and of fuel, also, if the efficiency of the boiler is given or calculable. The sum of the thermodynamic and the waste requirements, measures the cost of the work performed, either as the equivalent of the heat-transformation, as measured on the indicator diagram, or of the net useful work transferred through the machinery of transmission or measured by the Prony brake, the absorption dynamometer. The ratio of that sum to the work so measured, is the value of the efficiency of the system. The difference of efficiency among the several types or examples indicates the relative standing of those various examples and furnishes the basis for computation of the conditions of maximum efficiency of fluid, of engine, of plant, or of capital.

(*To be continued.*)

MEMOIR OF CYPRIEN CHABOT.

CYPRIEN CHABOT was born in 1824, at St. Clair, in the Province of Quebec, Canada.

At the age of 15 he went to the city of Quebec, and was apprenticed to Mr. Louis LeMoin, a general machinist and gunsmith of that city, who was not only a mechanic, but had considerable experience as a scientific investigator.

Whilst yet a boy in this place Mr. CHABOT made many mechanical constructions, evincing both inventive ability and skill beyond his years; in fact, whilst an apprentice he was the acting manager of Mr. LeMoin's workshop.

When 20 years of age Mr. LeMoin was so well pleased with his proficiency, that he placed at his disposal the means of going to Paris, in order that he might further perfect his knowledge of the art, where he remained more than a year, returning to Mr. Le Moin's establishment and remaining with him a year.

Mr. Le Moin, realizing that Mr. CHABOT was not working in a field adequate to his ability, recommended him to remove to the United States, where he could have better opportunities for advancement, which he did in 1846, locating in New York City, where he engaged in tool and die making, inventing and perfecting machinery for the manufacture of *porte-monnaie* frames and clasps, umbrella frames, and mountings and similar small metallic wares. He continued in this business until 1855, when he came to Philadelphia, and engaged in tool making for the manufacture of watch-cases, and by his improvements and perfections of workmanship, enforced by competition a better quality of manufacture than had ever before been known.

In 1862, he engaged, as a contractor, to make rifle and pistol parts in Christian Sharp's rifle factory, in West Philadelphia, and made many marked improvements in the tools, and improved the accuracy of the Sharp fire-arms, which then enjoyed the highest reputation.

From the Sharp's rifle factory Mr. CHABOT went, in the fall of 1864, to the American Arms Company, of this city, doing similar work on the Gallagher carbine. During this time the company developed into the American Button-Hole Machine Company.

Whilst this change was in progress, Mr. CHABOT improved the Springfield rifle, converting it from a muzzle-loading arm to a breech-loader; with this invention in hand he went to England, France and Switzerland, and submitted it to the several governments, as the agent of the American Arms Company, where the invention met with a high

appreciation. The close of the War of the Rebellion in the United States terminated the manufacture of arms for this company, and he then resumed the construction of special tools for the American Button-Hole and Overseaming Sewing Machine Company, after which he became a contractor for work in that factory.

After this he engaged as a partner in the making of tools for some new sewing-machines for the Philadelphia Sewing Machine Company. This company did not prove successful financially, after which he turned his attention to shoe-manufacturing machinery, and perfected two shoe-sole sewing-machines, a channelling machine, and an edge-turning machine, all of which are patented, and which have been recognized in the FRANKLIN INSTITUTE by the award of several medals. He also improved the Peerless brick machine, and made the best diamond-turning tools known.

In 1884, he again turned his attention to the watch-case manufacture, and perfected machines and dies for forming and turning the caps, bezels and centres of watch-cases, and changed the entire method of manufacture, so that the "filled" or "stiffened" watch-case of to-day, made interchangeably to suit all of the standard movements, had practically supplanted other cases in the trade, both by its improvements as well as its reduced cost; in short, there are few things in the arts which he has touched that he did not leave permanently and decidedly improved.

In the FRANKLIN INSTITUTE he has been long and well known as one of its most energetic and capable members, he has served several terms in the Board of Managers, and has been continuously one of the most efficient members of the Committee on Science and the Arts.

We part with him with a high appreciation of his character and a sense of deep regret for our loss.

S. LLOYD WIEGAND, *Chairman*,
WM. H. WAHL,
SAMUEL SARTAIN,
LUTHER L. CHENEY.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, December 17, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, December 17, 1889.

Mr. H. PEMBERTON, Jr., President, in the Chair.

Members present: Prof. E. F. Smith, Dr. L. B. Hall, Dr. H. W. Jayne, Dr. S. C. Hooker, Prof. N. Wiley Thomas, Mr. J. H. Eastwick, Mr. L. J. Matos, Mr. W. H. Bower, Mr. T. C. Palmer, Mr. Lucius E. Williams, Dr. D. K. Tuttle, Mr. G. L. Norris, Mr. F. C. Lewin, Dr. W. C. Day and a number of visitors.

An extract from a letter of Dr. Wahl to the Secretary was read, recommending the renewal of subscriptions to the various journals taken by the Section. On motion, it was decided to authorize Dr. Wahl to renew these subscriptions.

The Treasurer, Dr. Jayne, read his annual report, showing the present financial condition of the treasury. The report showed a total of receipts from various sources amounting to $181.35; disbursements amounting to $89.85; thus leaving a cash balance of $91.50 in the hands of the Treasurer at date. The number of members on the books January 1, 1889, was 55; of these 5 were dropped for non-payment of dues, 3 resigned; during 1889 24 new members were added to the list, making a total of 71 now on the roll.

The election of officers for the coming year was then proceeded with, Prof. N. Wiley Thomas and Mr. W. H. Bower being appointed by the President to serve as tellers. Balloting for President and two Vice Presidents resulted in the election of Mr. T. C. Palmer, President, and Dr. H. F. Keller and Mr. W. L. Rowland, Vice-Presidents.

On motion of Dr. Hall, it was decided that the Secretary cast the vote of the Section for the present incumbents of the offices of Secretary, Treasurer and Conservator.

Dr. S. C. Hooker called the attention of the Section to a note by Dr. Samuel Rideal in the *Chemical News*, of November 29, 1889, in which the author gave the quantitative results of a comparison of the so-called "phenol-

sulphuric acid" method and the "carbazol" method of determining nitrates in potable waters; the figures are as follows:

NITROGEN IN PARTS PER 100,000.

Sample.	*Phenol-Sulphuric Acid.*	*Dr. Hooker's Carbazol Process.*
1	0·025	0·0247
2	0·050	0·045
3	0·200	0·209
4	1·400	1·38
5	1·600	1·65

Dr. Hooker then spoke of some experiments which he had made with Mr. Geo. Bartram during the past summer, showing that the phenol-sulphuric-acid solution used in the well-known process above referred to, undergoes a change shortly after preparation, which causes the introduction of a very appreciable error in the presence of comparatively large quantities of chlorides. When the phenol solution is freshly prepared, chlorides do not influence the results. These experiments will be published in detail at a later date.

Prof. E. F. Smith read a paper giving additional results obtained by himself and Mr. Lee K. Frankel in making electrolytic separations of various metals. The paper was submitted for publication.

Mr. G. L. Norris then read a paper on "A Rapid Method for Determining Phosphorus in Iron and Steel," modified from a method proposed by Dr. Drown, at the meeting of the American Institute of Mining Engineers, June, 1889. This paper was also referred for publication.

Adjourned. Wm. C. Day, *Secretary.*

A RAPID METHOD FOR PHOSPHORUS IN IRON AND STEEL, MODIFIED FROM A METHOD PROPOSED BY DR. THOS. M. DROWN.

By G. L. Norris, Pencoyd, Pa.

[*Read at the Stated Meeting of the Chemical Section, December 17, 1889.*]

The new method for phosphorus described in Dr. Drown's paper before the Am. Inst. Min. Eng., June, 1889, and published in the *Technology Quarterly* for April, appeared to possess so much advantage over the Emmerton method in speed, that I determined to experiment with it, with the view of adopting it. My experiments convinced me that the 1·135 sp. gr. nitric acid, recommended by Dr. Drown, is superior to 1·20 sp. gr. nitric acid for dissolving pig-iron and

steel for phosphorus determinations. I also found that the addition of ammonia or the presence of ammonium nitrate was of no advantage.

Finally I adopted the following modified method, doing away entirely with the use of ammonia:

Five grams of pig-iron or steel are treated in a twelve-ounce covered beaker, with 90 cc. of 1·135 sp. gr. nitric acid for steels, 120 cc. for pig-irons. The beaker is heated on an iron plate until all action ceases and solution begins to boil. To the boiling solution 20 cc. of a solution of potassium permanganate, eight grams to the liter, are added. The solution is then boiled a few minutes, to be sure all the permanganate is used up. A precipitate of manganese peroxide must come down on boiling to be sure that all the phosphorus is oxidized. After boiling with permanganate, a small piece of tartaric acid is added, and the solution boiled a minute or two longer, until all the manganese peroxide is dissolved. The solution is then poured in a 500 cc. globe flask and 10 cc. of 1·40 sp. gr. nitric acid added. The solution in the flask should then be about 90 cc. in bulk. In case of pig-iron the solution is made up to 100 cc. with water, the graphite filtered off, and 80 cc. of the filtrate drawn off into a flask, and then 10 cc. of 1·40 sp. gr. nitric acid added. The solution is then heated to 90° C., and 80 cc. of ammonium molybdate solution added, the flask stoppered, wrapped in a cloth and shaken hard for five minutes. The molybdate solution is made by dissolving 100 grams molybdic acid in 400 cc. strong ammonia and then mixing with 1,200 cc. of 1·20 sp. gr. nitric acid. From this point on the method is the same as Emmerton's, reduction of the yellow precipitate with zinc and titration with a standardized permanganate of potassium solution.

For high phosphorus pig-iron only 1·25 grams are used and treated with 60 cc. of 1·135 sp. gr. nitric acid. The solution is made up to 100 cc., filtered, 80 cc. of the filtrate drawn off, and 10 cc. of 1·40 sp. gr. nitric acid added.

The only speed determination I have made was on a steel, and thirty-six minutes covered everything, weighing and all. The following analyses are all the check analyses I have made by this method.

	Emmerton Method.	New Method.
Open hearth steel,	·087	·086
		·087
		·085
		·087
		·086
		·088
		·086
		·087
		·087
		·086
		·087
		·087
		·088
Open hearth steel,	·051	·050
		·050
		·049
		·052
		·050
		·052
		·049
		·051
		·050
Open hearth steel,	·060	·062
		·061
		·060
Open hearth steel,	·063	·060
		·062
		·061
		·061
		·060
		·063
		·063
		·063
Crucible steel,	·076	·077
		·076
		·076
		·078
		·076
		·075
		·076
		·078
		·076
		·076
		·075
Bessemer steel,	·109	·109
		·109
		·108
		·109
		·110
		·107
		·109
		·110
		·109
Bessemer steel,	·105	·103
		·102
Clapp-Griffiths steel,	·273	·272
		·271
		·268
Bessemer pig-iron,	·023	·022
		·022
		·020
Bessemer pig-iron,	·094	·095
		·093
		·094
		·093
Bessemer pig-iron,	·043	·043
		·041
		·044
		·043
		·041
		·043
		·043
		·043
		·043
		·044
		·041
Swedes pig-iron,	·876	·874
		·873
		·875
		·877

NOTES AND COMMENTS.

CHEMISTRY.

COMMERCIAL QUERBRACHO EXTRACT AND ITS DETECTION. By J. A. Wilson (*Chemical News*, **60**, 251).—It occurred to the author that the existence of alkaloids in querbracho might afford a means of recognizing the extract, and thereby detecting it when used as an adulterant of logwood or fustic extract.

As the first step towards carrying out this theory, an attempt was made to detect the alkaloids in the commercial querbracho extract by applying the general method for the detection of alkaloids and glucosides.

The sample examined was from a reputable manufacturer, and yielded 1·86 per cent. ash (0·81 soluble, 1·03 insoluble). Alkalinity equal 0·37 per cent. K_2O. The total non-volatile solids amounted to 30·47 per cent.

Fifty grams of the extract were examined for alkaloids in the following manner:

(1) Evaporation in a vacuum at 50° C.

(2) Residue treated for eighteen hours with 150 cc. of 90 per cent. alcohol acidulated.

(3) The residue obtained on evaporating alcohol was treated for twelve hours, with six times its volume of water, and then filtered.

(4) The filtered liquid from (3) was acidified and agitated successively with petroleum ether, benzol, chloroform, etc.

(5) The liquid, after extraction in the acid state, was rendered strongly alkaline with ammonia and again agitated successively with the above immiscible solvents, the chloroform being quite warm.

On evaporating the solvents and testing the residues by the usual alkaloidal reagents, no trace of alkaloid was found.

The author offers no theory for his failure to obtain satisfactory results, and as the process is so plausible, it appears to deserve further trial on other samples. H. T.

BOOK NOTICES.

MACHINE DRAWING AND DESIGN. By Prof. William Ripper. D. Van Nostrand Company, New York.

This is intended as a course of instruction for technical schools and engineer students. It consists of a series of graduated exercises, extending over fifty-two plates, commencing with simple projection and advancing to the more difficult examples occurring in actual practice. The description of many of the plates is accompanied by perspective illustrations which greatly aid the student in forming a clear idea of the thing represented by the working drawings. Complete shop-drawings are given of a pair of small vertical

marine engines with link motion and reversing gear, and also of a screw-cutting lathe of English pattern.

These drawings are excellent in subject, arrangement and execution and are very well adapted for purposes of instruction. The text accompanying them is sufficient to give a clear understanding of the machines and their operation and of much of the theories underlying their design and the calculations for determining their proportions. The instruction in drawing, however, is deficient and very much of it is absolutely bad. In many respects it is contrary to the best examples among the plates to which it refers. For instance, it teaches the old system of projections, using the third angle, and of shade lines arranged to represent actual shadows that would be cast by the thing itself in nature, and strictly adheres to these principles in the first three plates, which are evidently drawn to suit the theories, while in all of the rest of the plates (which constitute the value of the book), the shade lines are distributed in the method which good draughtsmen employ, and in many of them the views are arranged in the common-sense manner, that is, of using the third angle and not the first. It is strange that most of the very individuals, whose function it is to mould the early impressions of engineer students, will persist in adhering to theories and methods which the most efficient experts have discarded, and will continue to teach a system and violate it in their illustrations, the latter inconsistency being probably due to the fact that their best illustrations are prepared by other parties who know better how to make a useful and clear drawing.

This book would be very strong if Sections 1, 2 and 3 of Chapter I, and Section 9 of Chapter IV were re-written on the same level as that of the plates.

W. H. T.

A Technical Dictionary of Fire Insurance.—Being a practical commentary, combined with a glossary of terms used in the principal manufacturing industries. By William A. Harris, of the Phœnix Fire Office. Liverpool; Published by the author. Thick 8 vo, Muslin.

An excellent work, in an almost unworked field of literature. The main insurance risks, mechanical, chemical, manufacturing, etc., are briefly given in alphabetical relation, and their most important jeopardies properly elucidated. For example: In blanket manufacturing it is shown that the sulphuring is a dangerous process added to the regular woollen-factory risk; blasting powders, after brief description of manufacture, are mentioned as more dangerous from the reckless handling usually given to them by miners. Charcoal grinding is of more jeopardy, from the fine, explosive dust; chemical works are difficult to enter, and about their processes the owners are always very reticent—inspectors should read up in chemistry somewhat before visiting these places; and so on for many pages. Such subjects as damaged cotton, danger from drying-rooms, saw-mills, sawdust, varnish, wool-washing, drying and carding machines, processes of cotton, woollen, linen, etc., factories, besides a multitude of others, like petroleum and its lamps, night work, personal hazard, etc., are all ably treated from the insurance standpoint, and in very condensed style.

The volume, therefore, will prove useful to insurance agents, solicitors, inspectors and surveyors; and not only to them, but also to many others. The mechanic, chemist and manufacturer are by it taught the insurance jeopardy of their work or processes; what risks to avoid, and also how to improve their establishments, so as to be more acceptable to underwriters, and become insured at premiums considerably less than establishments carelessly conducted. The world-wide reputation of Mr. Harris as an insurance expert, and his fire experience through many years connection with the Phœnix Fire Office—one of the best English fire insurance companies—is a good recommendation to his work, which will be properly appreciated the more it is examined. N.

A Chart Relative to the Composition, Digestibility and Nutritive Value of Food. Prepared by Prof. Henry A. Mott, Ph.D., LL.D., etc., etc.

This is a very compendious table, which would be more convenient for reference by the majority of those who use it were it not printed as a chart; though this method of presenting the facts has advantages for the organic chemist who is frequently engaged in the analysis of food stuffs, inasmuch as it enables him to suspend it on the wall of his laboratory. The first table exhibits Scammel's relative value of foods; the second, Lewes and Gilbert's composition of a hen's egg; the third, Fresenius' average composition of fruits; the fourth, Payen's composition of various kinds of cheese (and following it some analyses by Hornig and Voelcker of the same substance), warmth and strength derived from various articles of food and drink, percentage of nutrition in various articles of food, composition of various meats, composition of fish and shell-fish, composition of vegetables, composition of farinaceous foods, analysis of milk, ditto of products of the dairy, ditto of condensed milk, of American wines, composition of coffee, cocoa, and tea, standards for daily dietaries and for ordinary men doing moderate muscular work, etc., etc. It is a very convenient little chart for reference as well as a help to the scientific chemist. F.

Involuntary Idleness. An exposition of the discrepancy existing between the supply of and the demand for labor and its products. By Hugo Bilgram. J. B. Lippincott Company. 1889.

In this neatly-printed little book Mr. Bilgram seeks to show that the element which destroys the equal balance that should subsist between demand and supply is to be sought in the conditions which regulate the distribution of wealth. He dismisses the consideration of rent (one of the three divisions of wealth), on the ground that is not able to throw light on the apparent surfeit of all kinds of raw materials. He points out the ambiguous use of the term "capital" and discusses the causes for paying interest.

His conclusion is that the expansion of the volume of money by extending the issue of credit money will prevent business stagnation and involuntary idleness.

In all the numerous contributions of Mr. Bilgram to the science of economics there is a praiseworthy evidence of thought and the desire to do justice to all sides of the question. His expression of his thought is unusually clear, and his arguments have the ring both of a comprehension of this most difficult of subjects and of entire sincerity. F.

CALCARO'S SYSTEM OF PRESERVING GREEN FORAGE WITHOUT HEAT OR FERMENTATION BY THE USE OF THE SILO GOVERNOR. By Samuel W. Calcaro, Dover, Mass. Chicago, Howard & Wilson Publishing Company. 1889.

This book is devoted to a description and commendation of Mr. Calcaro's silo governor, which consists substantially of a system of perforated pipes disposed among the contents of the silo, by which—in combination with pressure by a series of jack-screws—it is claimed that the air is displaced by carbonic acid, that fermentation is prevented and that the material in the silo remains in its original condition, but softened and fully soaked in its own juices from the bottom to the top of the mass. The published recommendations speak very highly of the results attained and the nutritive character of the forage thus prepared. The theory and practice of Mr. Calcaro differ widely, it may be said radically, from theory and practice presented and recommended by authorities generally recognized as good in this matter. It is not for this JOURNAL to decide when the doctors in agriculture so disagree. L.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, December 18, 1889.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, December 18, 1889.

JOSEPH M. WILSON, President, in the Chair.

Present, 106 members and sixteen visitors.

Additions to membership since last report, forty.

Dr. THOMAS W. EVANS, of Paris, France, on the recommendation of the Board of Managers, was elected an honorary member of the INSTITUTE.

The Secretary, by direction of the Committee on Science and the Arts, reported the following action of the Committee upon the death of CYPRIEN CHABOT:

[Extract from the minutes of the Stated Meeting, held Wednesday, December 4, 1889.]

WHEREAS, the Committee on Science and the Arts has learned with great regret of the death of CYPRIEN CHABOT, one of its eldest and most

valued members, who, by his example and labors, and his exceptional ability and skill as a mechanic, during the many years of his active association with it as member, contributed in a large measure to its usefulness and to the maintenance of a high standard of excellence in its work; therefore,

Resolved, that the Committee on Science and the Arts hereby expresses its high appreciation of the most devoted, disinterested and able services of Mr. CHABOT;

Resolved, that the Committee hereby extends its sympathy to the family of the deceased member;

Resolved, that the Committee's action be spread upon the minutes, and reported to the next stated meeting of the INSTITUTE; and,

Resolved, that a committee be appointed to prepare a suitable memoir of the deceased for publication in the JOURNAL.

The foregoing preamble and resolutions were endorsed and directed to be entered upon the minutes of the meeting. The Secretary thereupon presented a memoir of Mr. CHABOT, which was on motion referred to the Committee on Publication. (The memoir appears elsewhere in this impression of the JOURNAL.)

An election to fill the vacancy in the Board of Managers by the death of Mr. CHABOT resulted in the choice of Mr. STACEY REEVES; and the vacancy caused in the Committee on Science and the Arts was filled by the election of Mr. F. LYNWOOD GARRISON.

The following nominations were made for officers, managers and members of the Committee on Science and the Arts, to be chosen at the annual election to be held on Wednesday, January 15, 1890, viz:

For *President* (to serve one year), ... JOSEPH M. WILSON.
For *Vice-President* (to serve three years), . CHARLES BULLOCK.
For *Secretary* (to serve one year), ... WM. H. WAHL.
For *Treasurer* (to serve one year), . . . SAMUEL SARTAIN.
For *Auditors* (to serve three years), . . { WM. B. COOPER (declined), SAMUEL H. NEEDLES.

For *Managers* (to serve three years):

CHAS. H. BANES,	THEO. D. RAND,
WASHINGTON JONES,	COLEMAN SELLERS,
EDWARD LONGSTRETH,	STACEY REEVES,
ISAAC NORRIS, JR.,	S. LLOYD WIEGAND,
A. E. OUTERBRIDGE, JR.,	F. LYNWOOD GARRISON.

For members of the *Committee on Science and the Arts* (to serve three years):

ARTHUR BEARDSLEY,	LEWIS M. HAUPT	WM. H. WAHL,
HUGO BILGRAM,	(declined),	JOHN H. COOPER,
J. H. EASTWICK,	RUFUS HILL,	F. LYNWOOD GARRISON,